INTERNATIONAL
Marine Engineering

Volume XXV AUGUST, 1920 Number 8

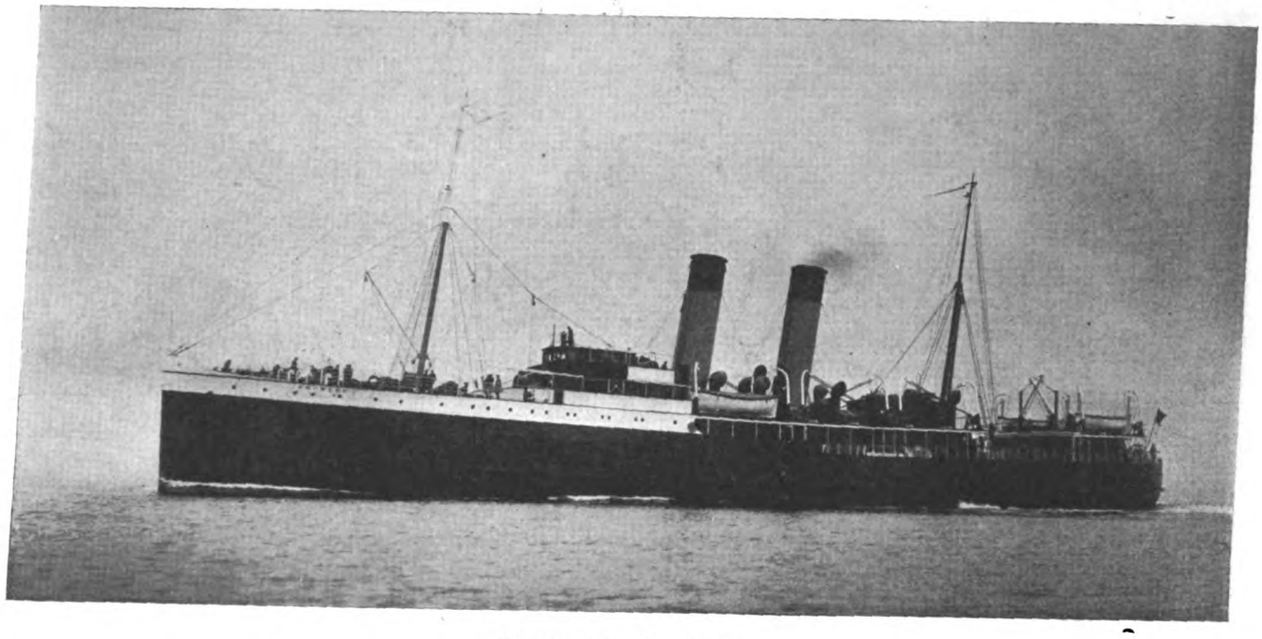

Fig. 1.—Steamship *Antwerp*

Geared Turbine Passenger Steamer Antwerp

The First of Three New Steamships for the Harwich-Antwerp Service of the Great Eastern Railway of England

BY FREDERICK C. COLEMAN

THE Continental traffic facilities of the Great Eastern Railway Company of England have been materially improved by the introduction on May 31 in the Harwich-Antwerp service of the new geared turbine steamship *Antwerp*, recently built by Messrs. John Brown and Company, Limited, of Clydebank, Scotland, a description and illustrations of which we are privileged to publish in this issue.

War Services of the Great Eastern Railway Fleet

It is well within common knowledge that the Great Eastern Railway Company's fleet of steamships suffered somewhat severely during the war period. Of the mail steamers, the *Copenhagen*, the *Dresden* (renamed *Louvain*) and the *Colchester* were sunk, while the *Brussels* was captured by the enemy, but has just been restored by the Belgian authorities to the British Government. The cargo steamers *Clacton* and *Newmarket* were also sunk. The passenger and mail services between Harwich and the Hook of Holland and Antwerp respectively are now worked by the steamships *Archangel* (previously *St. Petersburg*), *St. Denis* (*Munich*), *St. George*, *Amsterdam*, *Roulers* (*Vienna*), *Frinton* and *Brussels*.

The New Steamship

The *Antwerp* is a twin screw steamship 320 feet in length between perpendiculars, 43 feet in breadth, and 26 feet 6 inches from keel to shelter deck, with midship deck house and boat deck extending for about 160 feet, and continued as a forecastle deck. The *Antwerp* is one of three new turbine steamships ordered by the Great Eastern Railway; the second vessel, the *Bruges*, was launched at Clydebank in March last and is expected to be ready for service in August, while a third sister vessel is on order from Sir W. G. Armstrong, Whitworth and Company, Limited, of Newcastle-upon-Tyne.

Construction Details

Each of these three new steamships will have a speed equivalent to the company's boats now used on the Hook of Holland route, and greater than that of any vessels previously in service between Harwich and Antwerp. The general arrangement and constructional details are illustrated in the drawings on pages 626A and B and 627, while photographs giving typical views of the public rooms and also of the geared turbine machinery are reproduced on pages 626 to 630. It will be seen that the hull has a straight stem and a cruiser stern. The vessel was built to Lloyd's rules and special survey for an A-1 shelter deck class.

Accommodations are arranged for 262 first-class and 102 second-class passengers. The first-class dining saloon is on the shelter deck forward, extending from side to side of the vessel, with sitting accommodations for 72 passengers. The walls are panelled in mahogany and satin-

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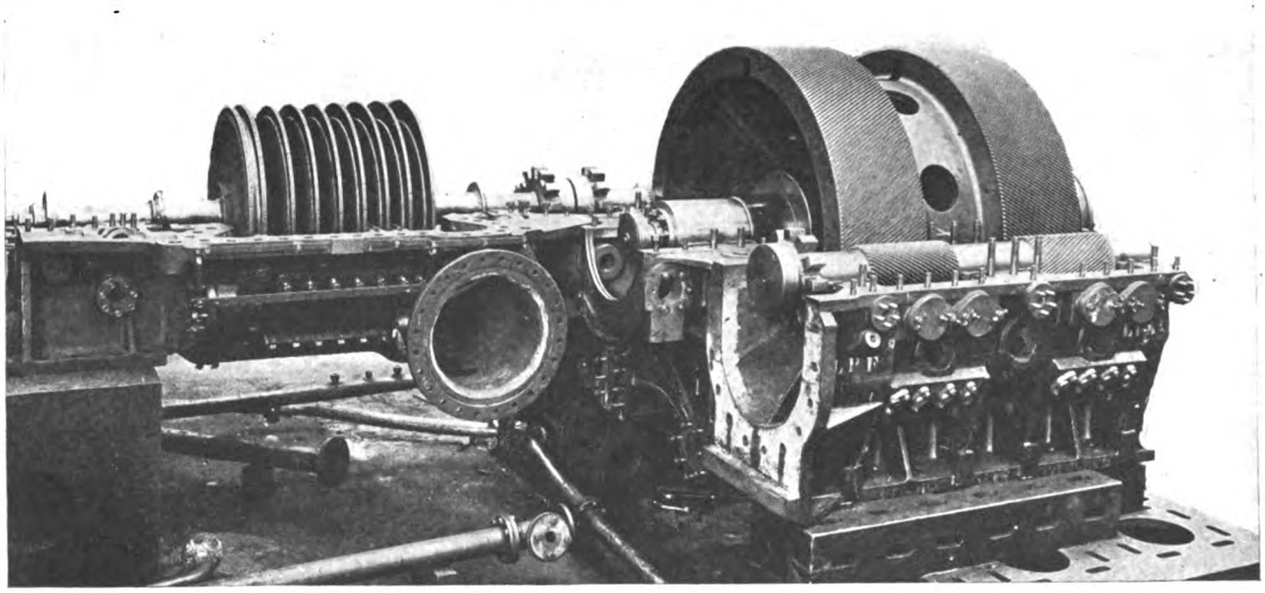

Fig. 2.—High Pressure Turbine and Gearing with Covers Lifted Showing Turbine Rotor, Main Gear Wheel and Low Pressure Pinion

wood. The ceiling is finished in white. An electric "Magicoal" fireplace is arranged at the fore end of the saloon, which has an oak parquetry floor, and there are sofa seats and chairs upholstered in tapestry.

PASSENGER ACCOMMODATIONS

The first-class smoking room is situated on the shelter deck between the forward and after funnel casings and is panelled in oak, Jacobean style. There is a large, leaded, glass-domed skylight. A large fireplace, with stone jambs, is fitted with armor bright dog grate and club fender seating. The settees and chairs are upholstered in dark blue morocco. Axminster carpet runners are laid over an oak and walnut parquetry floor.

The first-class ladies' room is on the port side of the main deck forward. The walls are painted white with silk tapestry panels. The furniture is of polished mahogany and the settees are upholstered in tapestry. An electric "Magicoal" fireplace is fitted at the forward end.

The first-class lounge is situated in the deckhouse on the boat deck in way of the first-class entrance and stairway. From this space a door leads to a cabine de luxe, which

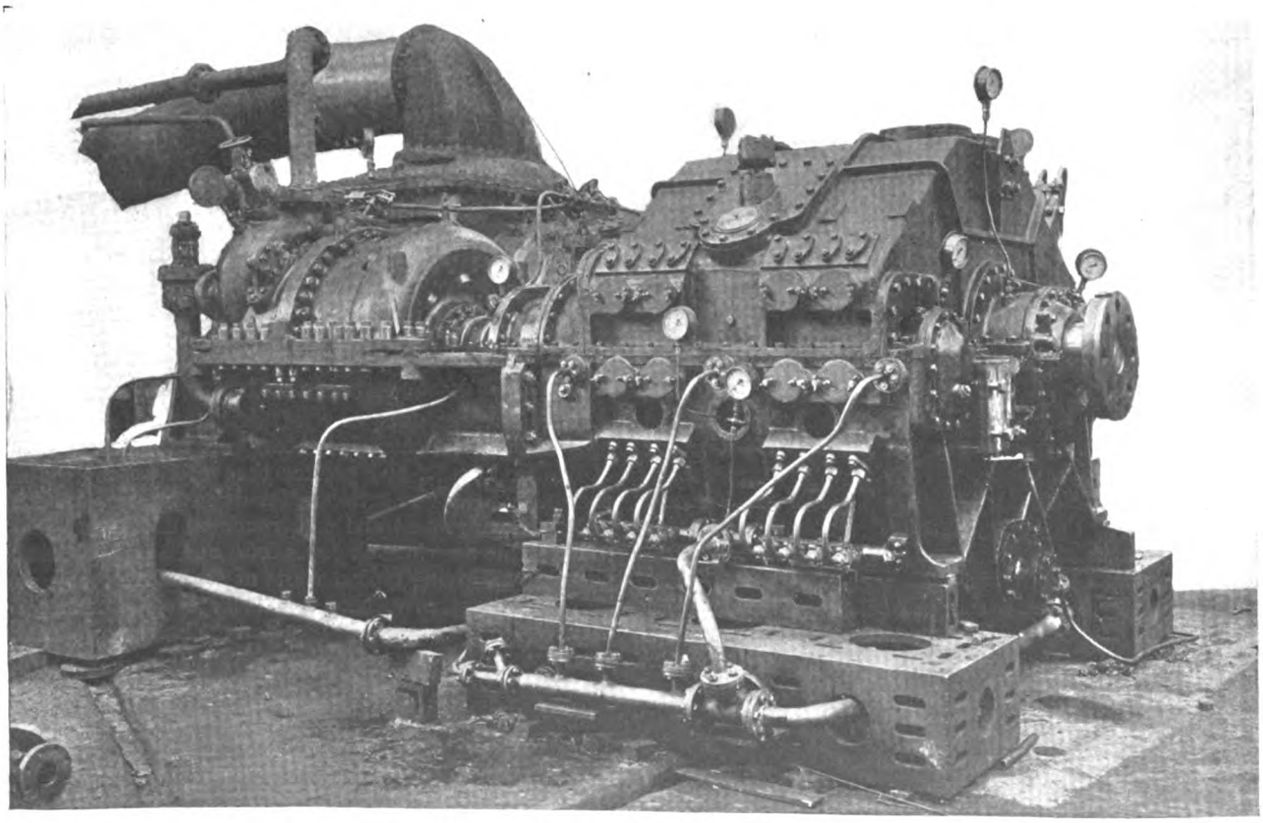

Fig. 3.—Full Set of Main Propelling Machinery Assembled in the Shop at Clydebank

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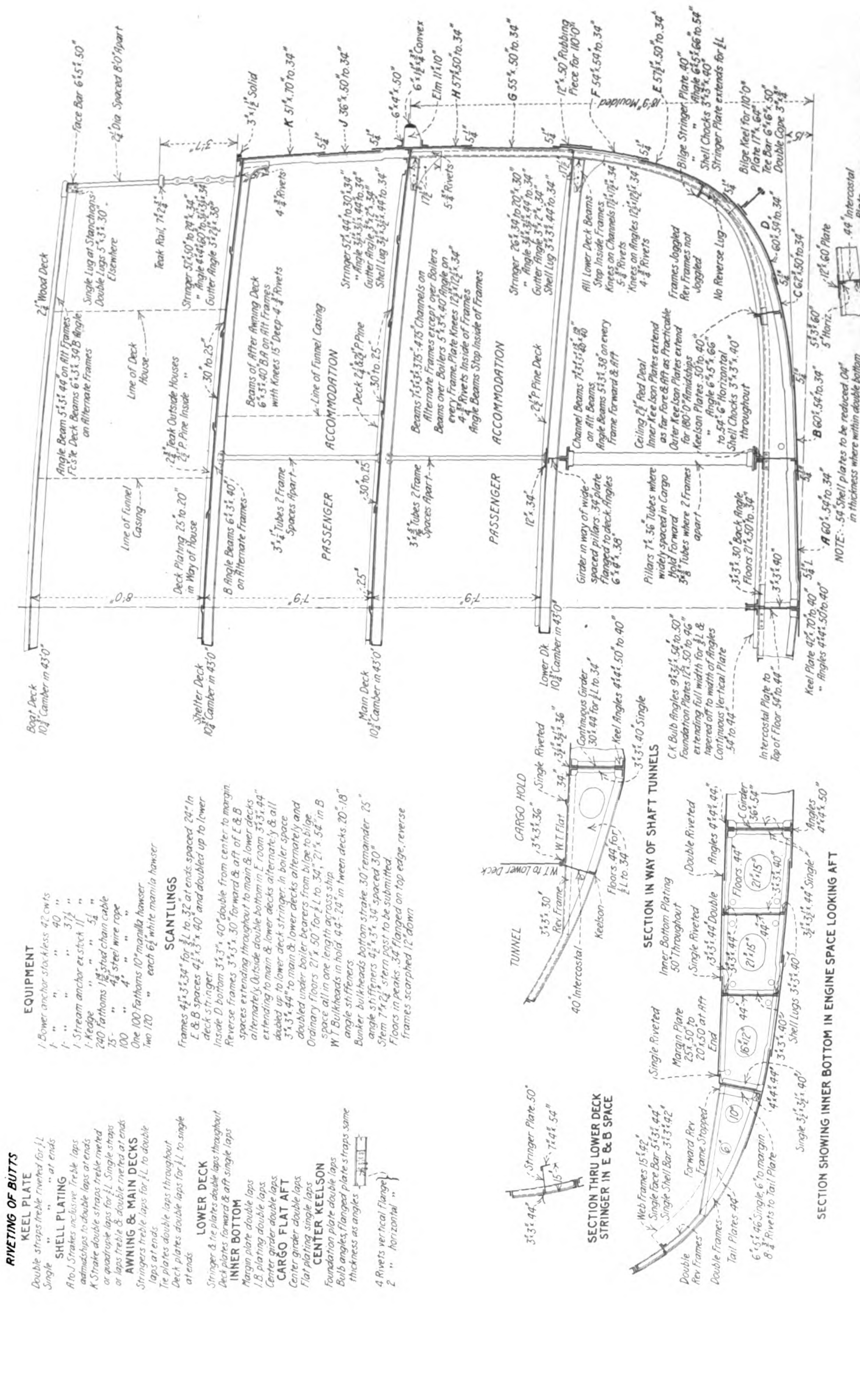

Fig. 6.—Midship Section, S. S. *Antwerp*

Fig. 7.—First-Class Entrance and Lounge on Boat Deck

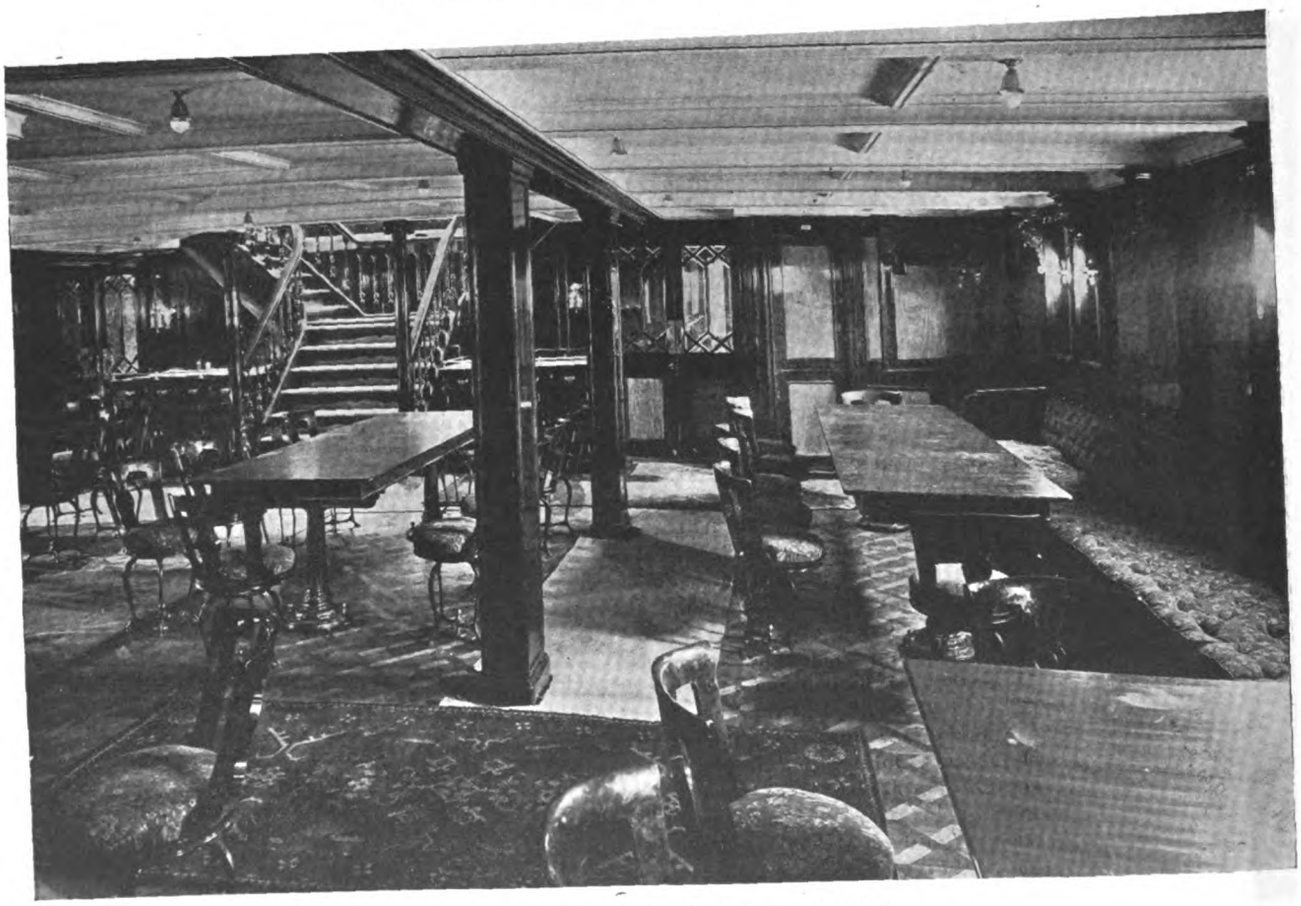

Fig. 8.—First-Class Dining Saloon on Shelter Deck

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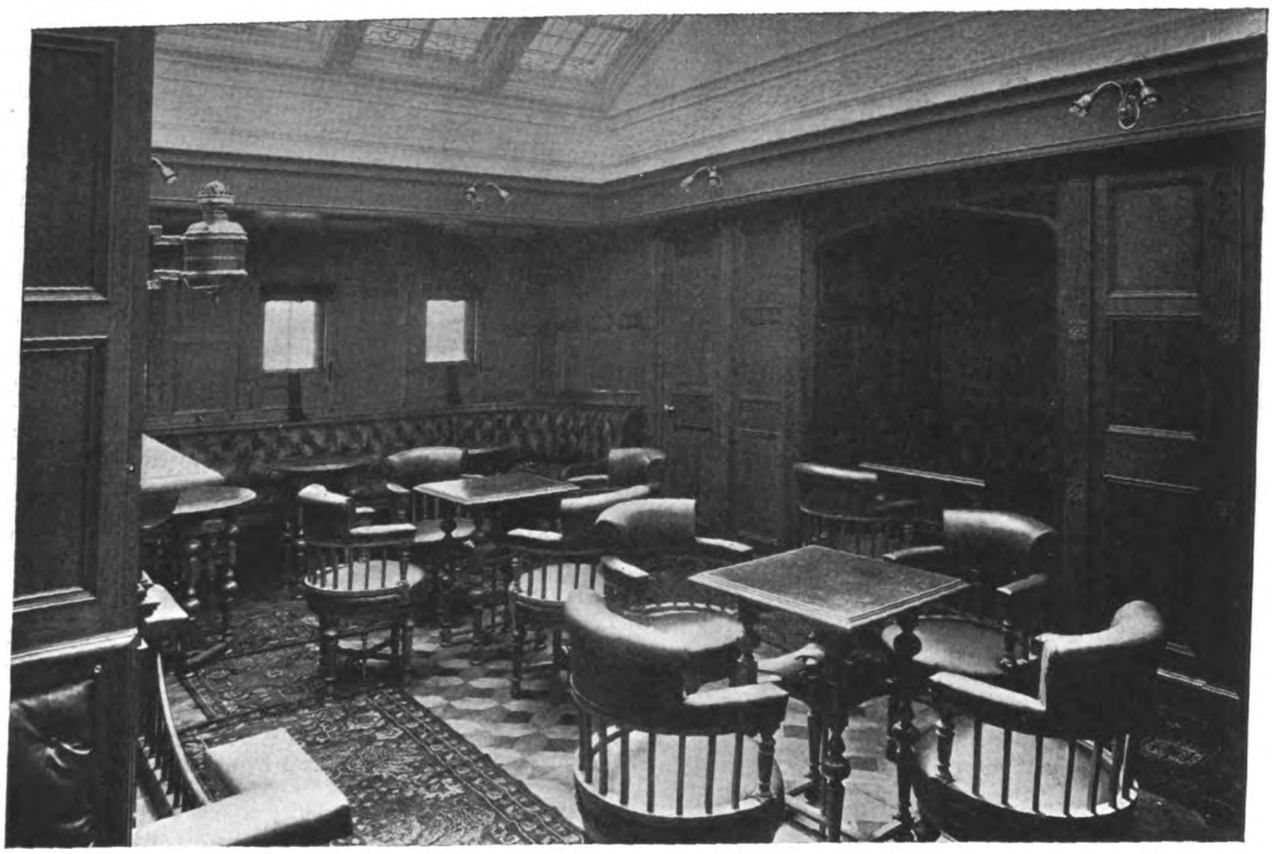

Fig. 9.—First-Class Smoking Room, Aft End

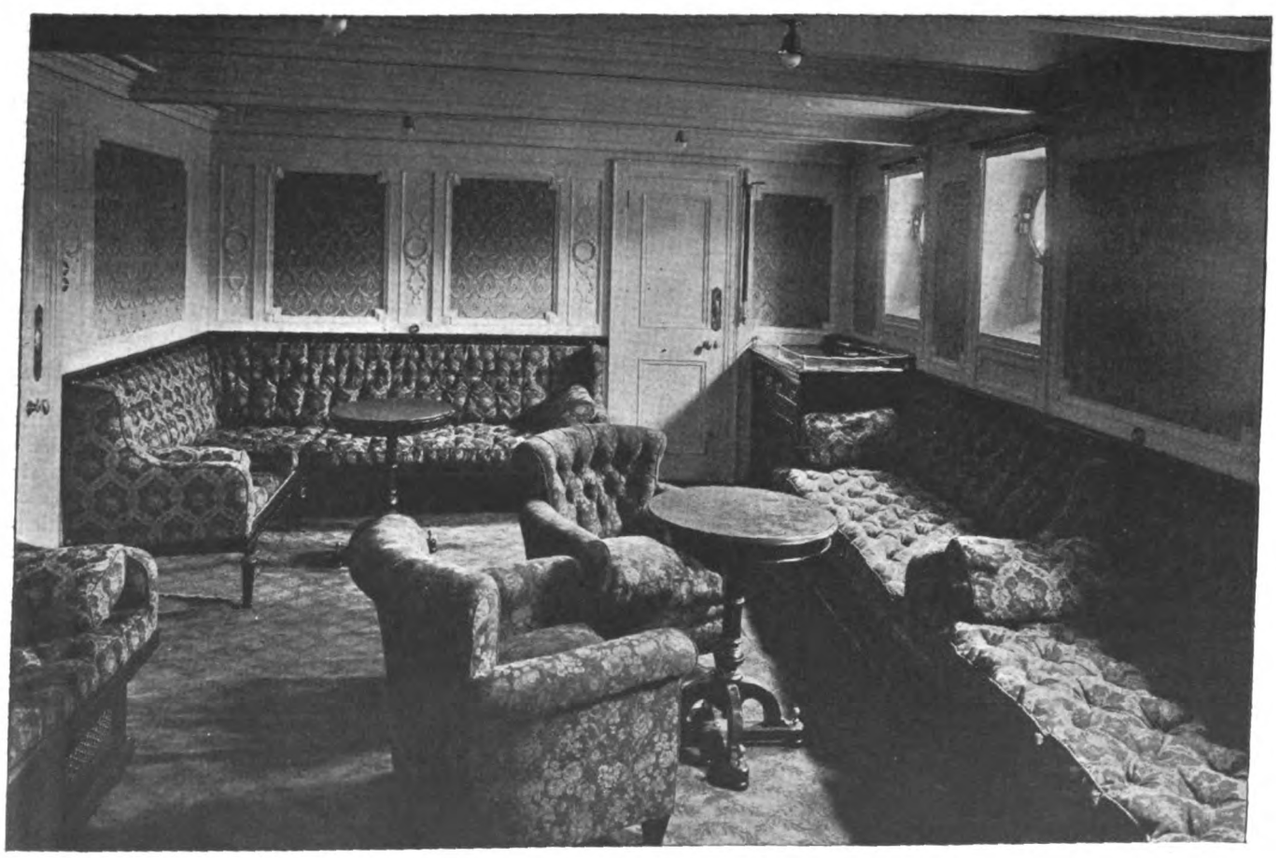

Fig. 10.—First-Class Ladies Room on Main Deck

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has two large polished wood cot beds and handsome writing and dressing tables and wardrobes. The walls and ceiling are white enamel and the floor is covered with blue Wilton carpet.

The first-class staterooms are arranged as one, two, three and four-berth rooms on the shelter, main and lower decks. The walls are neatly panelled and finished in white enamel. The floors are covered with red Brussels carpet and the seats, etc., are upholstered in moquette or cretonne.

The second-class cabins are situated on the main and lower decks aft. The woodwork is finished in white enamel and the floors are laid with Brussels carpet runners. The sofas, chairs, etc., are upholstered in railway repp. The second-class dining saloon, on the port side of the main deck aft, which seats forty passengers, is finished and upholstered in a similar manner to the cabins in its vicinity. The second-class entrances, ladies' room and smoking room are situated in the deckhouse on the shelter deck aft. The floor of the ladies' room is laid with Brussels carpet runners and the sofas, etc., are upholstered in railway repp.

Fig. 11.—Fireplace, First-Class Smoking Room

Officers' and Crew's Quarters

The captain's cabin is on the bridge immediately behind the chart room, the chief and second officers are accommodated in cabins in a house on the boat deck and the engineer officers in cabins on the starboard side of the main deck. The seamen are accommodated on the shelter deck forward and the firemen and greasers on the main deck amidships.

There are eight lifeboats, each 28 feet long, carried on Welin davits on the boat deck, and lifeboats are provided for everyone on board.

Arrangements are made whereby ninety horses can be carried in separate stalls, forty-four on the main deck and forty-six on the lower deck, and the hatchways and gangways are designed to ensure their safe handling and embarkation.

An efficient scheme of ventilation on the thermotank system is installed. By means of five thermotanks the air (which can be heated, if necessary) is conveyed in trunks to the various compartments. In way of the first-class accommodations the thermotanks are arranged in pairs so that either or both thermotanks can be used to supply air to that particular section of accommodation.

All the watertight doors are operated on "Stone's" patent system controlled from the bridge. The steering gear, of the Williams-Janney electro-hydraulic type, is fitted on the lower deck aft, controlled by hand and telemotor on the quarter deck and by telemotor from the bridge. A spare motor is fitted in the event of a breakdown.

There are five hatches with a steam winch and a derrick at each hatch. For heavy loads the derrick at the main hatch is specially designed to be capable of handling loads of ten tons.

The vessel is fitted with the Marconi wireless apparatus, comprising two microphones on the ship's side connected electrically to receivers in the chartroom. There is also a submarine sound signalling set.

A storage battery is fitted for emergency lighting, and this has a discharge capacity of 240 ampere hours, equivalent to the maintenance of two hundred 20-watt metallic lamps for six hours.

The Turbine Machinery

The *Antwerp* is of interest as being the first geared turbine steamship of the Great Eastern Railway Company. The main propelling machinery consists of two sets of Brown-Curtis turbines of the latest type, transmitting the power developed through single reduction gearing to the propeller shafts. Each set consists of high pressure and low pressure turbines for ahead working and a turbine for astern working, the high pressure turbine being connected to one pinion of the gearing and the low pressure turbine for ahead working and the turbine for astern working, incorporated in the same casing, being connected with the other pinion of the gearing. Figs. 2 and 3 show this machinery assembled for steam balancing in the fitting shop at Clydebank, Fig. 3 showing an external view of the machinery and Fig. 2 a view of the high pressure turbine with cover removed and the gearing with cover removed.

A condenser of the uniflux type is fitted for each set of turbines and connected by exhaust pipe to the exhaust port of the low pressure and astern turbine casing. With each condenser a centrifugal circulating pump and an air pump of the dual type are fitted.

There is a complete installation for the forced lubrication of the turbine and gearing bearings, and the teeth of the gear wheels and pinions, comprising oil pumps, water service pumps, oil coolers and filters. Feed pumps are also fitted in the engine room, together with the usual adequate equipment of auxiliary pumps, etc.

The boiler installation consists of five single-ended boilers of the cylindrical return tube type and a small donkey boiler arranged to work under the closed stokehold system with the usual fittings for coal burning.

The vessel successfully carried out her steam trials on the Firth of Clyde, when she attained a speed of 21½ knots between the Cloch and Cumbrae Lights on a run of 6 hours duration at a service draft of 14 feet.

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Electric Drive Applied to a Trawler

Description of the First Electrically Operated Trawler in the United States—Generators Driven by Eight Cylinder Diesel Engines

BY fitting out the trawler *Mariner*, a wooden vessel of 500 tons displacement built by Arthur D. Story, of Essex, Mass., with electric machinery both for propulsion and for handling the fishing gear, a new application has been found for electricity in the marine field. Not only is all of the machinery on the vessel operated by electricity, but the electric generators are driven by Diesel engines, so that this vessel becomes the first commercial application of the Diesel electric form of drive which has already been installed to a limited extent in pleasure vessels. The electric equipment for the *Mariner* was supplied by the General Electric Company, Schenectady, N. Y., and the Diesel engines by the New London Ship & Engine Company, Groton, Conn.

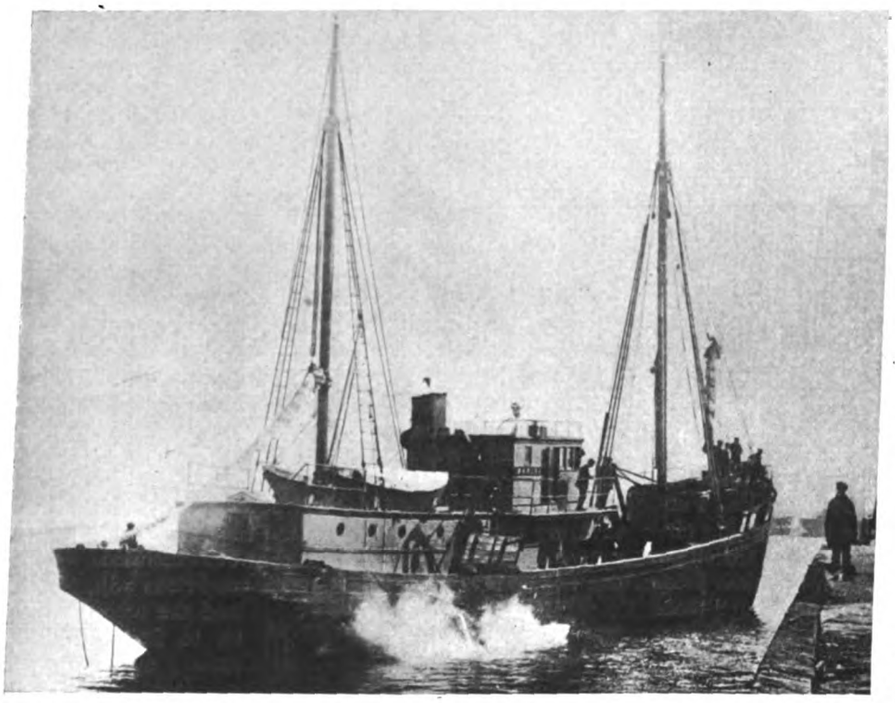

Fig. 1.—Electrically Propelled and Operated Trawler *Mariner*

The principal dimensions and characteristics of the vessel are as follows:

Length overall	150 feet 0 inches
Length on load waterline	140 feet 0 inches
Beam	24 feet 3 inches
Mean draft	11 feet 9 inches
Displacement	500 tons
Cruising radius at 10 knots	6,000 miles
Cruising radius at 7.5 knots	9,000 miles

Accommodations

The engineer's quarters are located right aft of the engine room beneath the after deck house. The captain's cabin is on top of the after deck house abaft the wheel house, while the crew are forward in the forecastle below the main deck. The galley is in the after deck house.

Propelling Machinery

The propelling machinery consists of two eight cylinder, four cycle Nelseco Diesel engines, rated at 240 brake horsepower at 350 revolutions per minute. These engines are direct connected to two generators, each generator being rated at 165 kilowatts at 125 volts. For propulsion, these two generators are run in series and supply power to the main motor, which is rated at 400 brake horsepower at 200 revolutions per minute. The rated voltage on the motor is thus 250 volts. If so desired, the main motor can be run at any reduced voltage, and in case the maximum impressed voltage on the motor does not exceed 125 volts, then one of the generator units can be shut down entirely and the motor operated entirely from the other generator unit. Connections are supplied and means of adjustment are provided so that any range of voltage and current can be supplied to the main motor and the load divided up on the main generating units as desired.

The main motor is placed at the forward end of the engine room with the line shafting running down between the generator units. The main generator units are placed with the generators forward adjacent to the main motor and the switchboard is placed on the starboard side of the vessel at the forward end of the engine room so that all electrical leads to and from the motor and generators are as short and direct as possible.

There are several reasons for placing the motor at the forward end of the engine room. In the first place, the lines of the vessel are so fine aft that it would be impossible to locate the motor and generator units to advantage in any other way. Secondly, the thrust bearing is placed adjacent to the main motor and with this arrangement it is only necessary to lift a section of line shafting in order to be able to draw the tail shaft into the boat and remove it. The shipowner will readily appreciate this point. Another reason for locating the electrical machinery at the forward end of the engine room is that it places it higher above the lowest point of the bilge so that any bilge water, etc., will readily drain away from the machinery. This arrangement of machinery gives ample room around every part, and the advantage of this when it comes to the care of the machinery during operation and when overhauling is readily appreciated by all members of the engineering force.

Both the generators and the motors are designed specifically for sea duty, and are provided with non-corrosive fittings and heat resisting insulator throughout. The bearings are so constructed as not to leak oil when the ship pitches. The machines are designed so as to be waterproof and to prevent flashing in a moist atmosphere, or when the engine room is flooded in heavy weather.

Another important point in connection with this installation is that a large motor—that is to say, about 100 horsepower—is required for the winch for handling the

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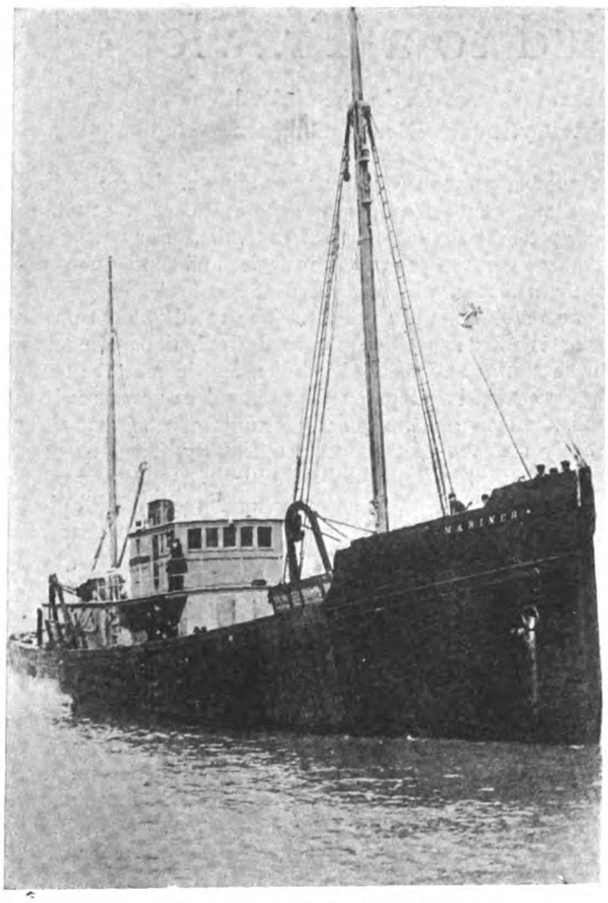

Fig. 2.—Bow View of *Mariner*

trawl. This motor is a 125-volt machine and takes its power from either one of the main generating units. Furthermore, all the other auxiliary power and lighting circuits on the boat are of 125 volts, so that power for either the lights or the auxiliary machinery can be taken from either one of the main generating units even though these main generating units may be supplying power to the propelling motor. Furthermore, there is a small auxiliary generating set, consisting of a 15-horsepower Fairbanks-Morse type *Y* engine driving a 10-kilowatt, 125 volt generator by means of a silent chain. This auxiliary unit will be required only when in port and both of the main generating units are shut down. At sea the two main generating units will be running most of the time, and in any case one will have to be running, and at that time all the power required for both lights and auxiliary power can be taken from either one of the units.

Advantages of Machinery Arrangement

It will be readily seen that this is a very flexible arrangement and not only provides great security against total failure but also requires a minimum amount of machinery to be in operation at any time. It also means that whatever machinery is in operation will be loaded up to good advantage and thus obtain good fuel economy. The auxiliary engine uses the same fuel as the main engines.

There is a small motor driven emergency air compressor which can be used in cases of emergency to fill the air starting bottles. While, with the two engines available for generating power, there is very little likelihood of a total loss of starting air or even a lack of spray air due to the breaking down of the regular compressor equipment, at the same time, if by any chance all starting air is lost, the auxiliary generating unit can be started by hand, which will supply power for the emergency compressor set and thus obtain starting air enough to start one generating unit and then the other. The air compressors on the main generators are of very large capacity, so that even though both compressors on one engine fail, there will still be enough spray air available from the other unit to keep both units going at slightly reduced power.

With all these arrangements it is almost impossible to conceive a situation where all power will be lost and the ship unable to make its own way to port. Of course, there is only one propelling motor and one propeller, but since the motor is of such very heavy duty type there seems to be little likelihood of anything of this kind happening, and certainly the ship is far better off in this regard than even the single screw steam reciprocating engined vessel.

Trial Trip

The official trial of the *Mariner* was held on November 29, 1919. Dock trials had been held previously, but this was the first real test at sea, and the ship lived up to expectations in every way.

The first test was more of an endurance trial, during which the engines were operated at increasing power, finally working up to full power and speed, which was maintained for several hours. The speed of the boat was a little over ten knots and was obtained on about 195 turns of the propeller, which is a three-bladed, cast iron wheel, 94 inches diameter by 68 inches pitch. The ship ran very steadily and the general absence of vibration was very noticeable. In fact, at any part of the ship except in the immediate vicinity of the engine room there was nothing to indicate the presence of any power in the vessel. The fuel consumption at full power amounted to about 30 gallons per hour, and on the basis of the fuel tank capacity of 17,000 gallons gives a radius of action of about 6,000 sea miles.

At the conclusion of the full power test various maneuvering trials were held and the capabilities of the arrangement in this line were amply demonstrated. With one engine shut down entirely and conditions adjusted to load the other engine up to full power, a little over three-quarters speed was attained. The economy of such an arrangement is at once apparent, since the fuel consumption was cut in half and the speed was reduced only about 25 percent, thus giving a radius at this speed of nearly 9,000 nautical miles, which is something of an achievement for a boat only 140 feet long and displacing only one hundred and fifty tons.

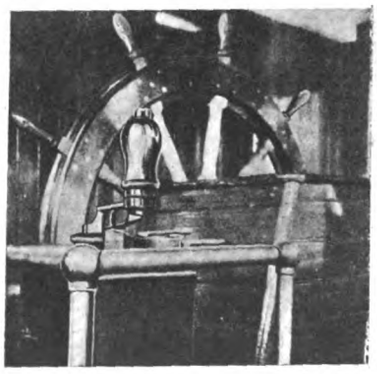

Fig. 3.—Steering Wheel and Speed Controller in the Pilot House

Quick reversing trials were also held. In connection with this, it should be noted that the control of the motor is carried right up to the pilot house and there all movements of the main motor are controlled by a controller which looks very much like the ordinary trolley car controller. There is a small lever which determines ahead, stop or astern rotation and also the regular controller handle which determines the speed. Electrical instruments are fitted adjacent to this controller in the pilot

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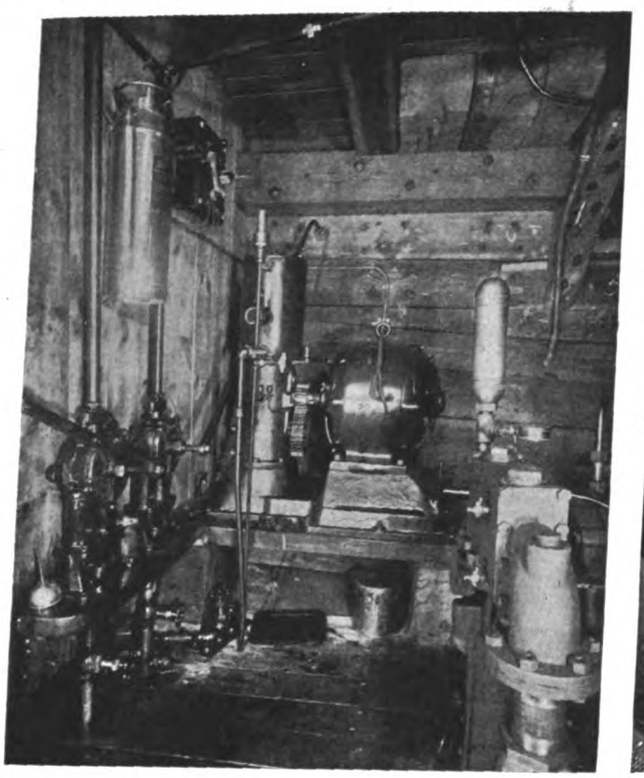

Fig. 4.—Auxiliary Air Compressor

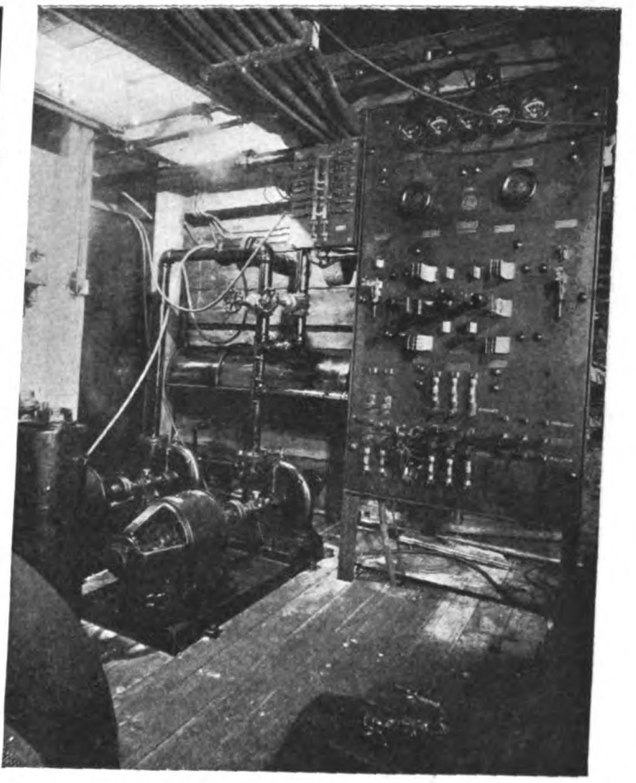

Fig. 5.—Main Switch Board

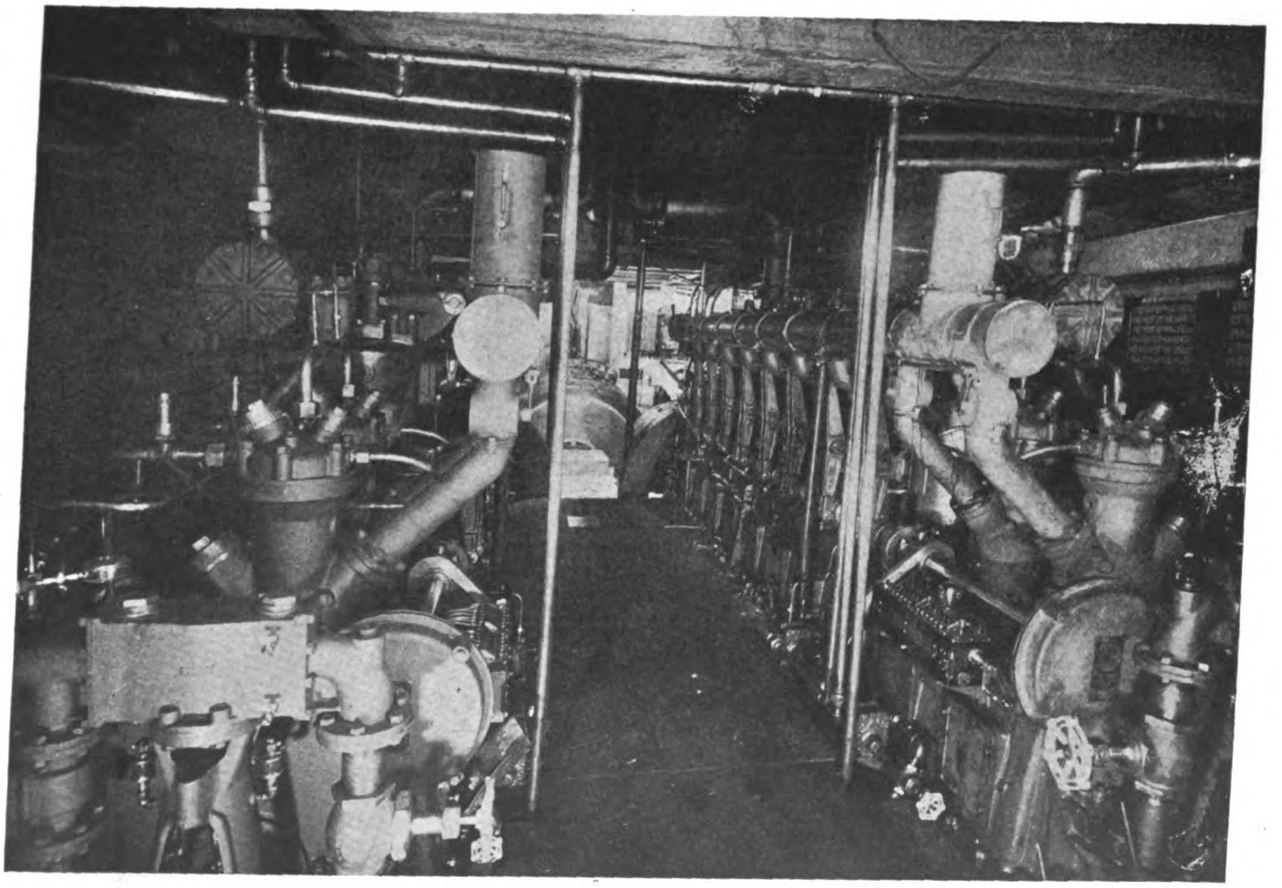

Fig. 6.—Main Engines of 240 Brake Horsepower Each, Looking Forward

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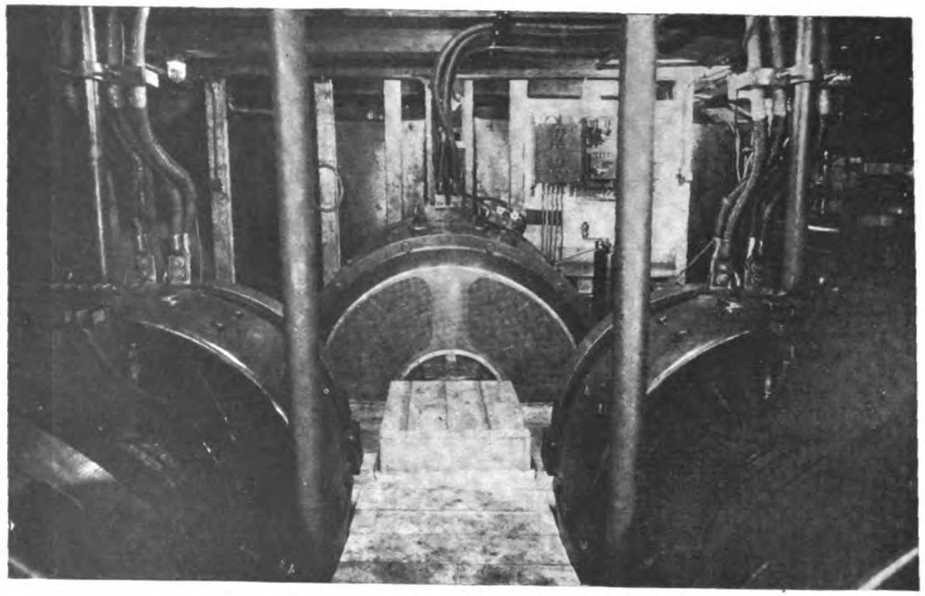

Fig. 7.—Generators and Motor, Looking Forward

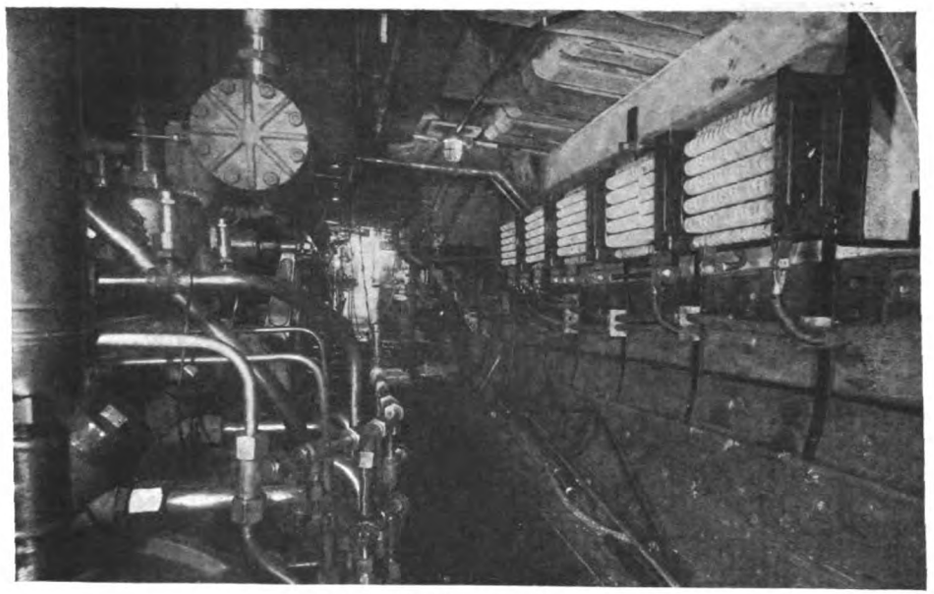

Fig. 8.—Resistance Boxes

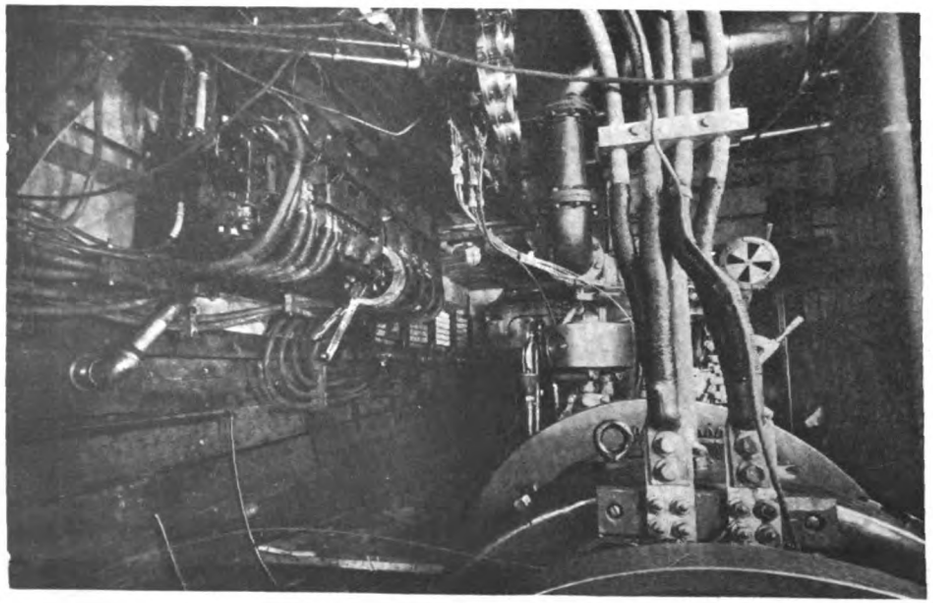

Fig. 9.—Contactor Panel

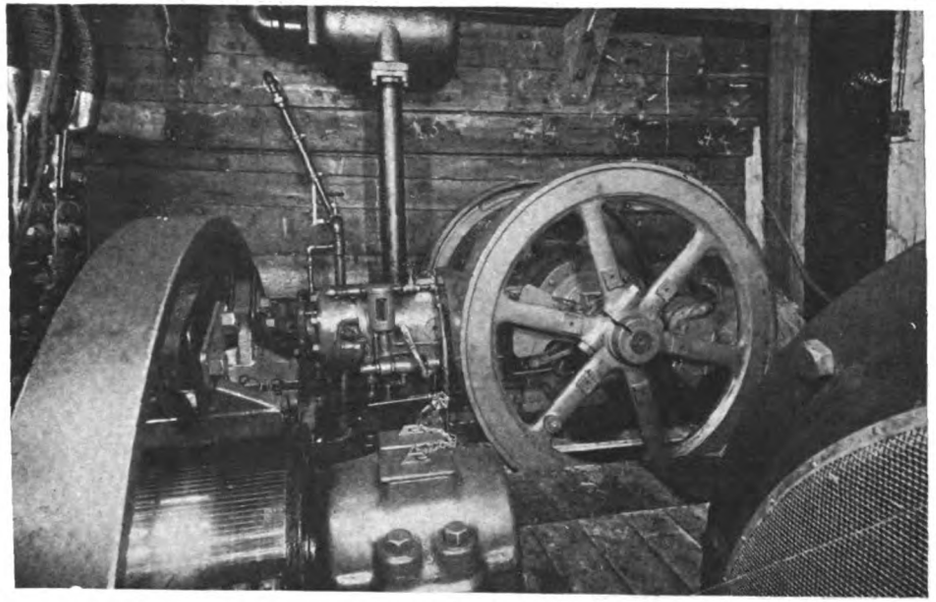

Fig. 10.—Auxiliary Lighting Set

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house showing the conditions at all times, so that the captain can see at a glance just what generator units are running, how much load they are carrying and just what the main propelling motor is doing.

QUICK REVERSAL OF THE VESSEL

It was found on the average of several trials that starting with the ship going full speed ahead it took on an average of two seconds from the time when the signal was given to the time when the propeller started in the reverse direction and, furthermore, it took from 15 to 18 seconds, starting with the ship going full speed ahead, from the time when the signal was given to the time when the propeller had been reversed and the main motor was developing full power and speed astern. Of course, during the time that the motor was being worked up to full power and speed astern the ship was losing way, and by this time the ship had lost most of its headway and was fast coming to a standstill.

An important point in connection with this control gear in the pilot house is the automatic re-setting of the circuit breakers in case it is accidentally tripped by supplying power to the motor too fast, by simply bringing the controller back to the stop position. In this way no time is lost and it is not necessary to wait for somebody in the engine room to re-set the circuit breakers. The advantage of this when maneuvering in close quarters is readily appreciated.

It was also interesting to be down in the engine room during these quick reversing trials. The main generating units ran on the governors at all times and the engineers had only to give the engines the usual attention while running. They did not know, unless they happened to look at the switchboard, what load the engines were carrying, since this was taken care of by the control in the pilot house. The electrical apparatus, of course, gave no indication whatever in regard to changes in load or reversal of speed in connection with the main motor, and the only indications that the engines gave that the load had been suddenly thrown on or off in maneuvering was the slight change in sound of the engines due to the slight change of speed. In fact, the ordinary observer in the engine room, unless he happened to be watching the electrical instruments on the switchboard, had no means of knowing that the boat was being maneuvered or, in fact, whether or not the main motor was running.

At the conclusion of her trials, the *Mariner* returned to her dock in New London and after some minor fitting out left on December 3 for Gloucester, where the winch and other gear for handling the trawls were installed.

CONTROL OF MAIN MOTOR

It should be stated that there is a controller in the engine room for handling the main motor, similar to the one in the pilot house, so that if desired the captain can give the usual gong signals to the engine room and the engineers can control the main motor with the controller there. The change from engine room to pilot house control is accomplished by simply throwing a switch on the engine room switchboard.

The fishing operations are carried on by means of a motor driven main double drum hoist, installed on the main deck forward of the engine room, which handles the haulage cables and ropes of the net as they pass through the hoist brackets fore and aft on either side. The unloading of the fish at the dock is accomplished by means of a motor-driven whip hoist located near the forward mast.

Cunard Liner Aquitania, Converted to an Oil Burner, Returns to Service

SINCE the end of November, 1919, the *Aquitania*, the largest vessel of the Cunard fleet, has been lying in the Tyne at the Walker yard of Messrs. Armstrong, Whitworth & Company, where her boilers have been converted to oil burners and she has been reconditioned for her regular transatlantic passenger service after her war service as an armored merchant cruiser, hospital ship and transport. The vessel sailed from Liverpool for New York on July 17.

Some idea of the magnitude of the job in converting this vessel into an oil burner may be gained from the fact that her boiler plant comprises 21 double ended Scotch boilers, each with 8 furnaces—making 168 furnaces in all—necessitating the laying of approximately 16 miles of piping with the necessary pumps, settling tanks and oil bunkers for handling 7,000 tons of oil. The oil is carried in the side bunkers, formerly used for coal, and also in six double bottom tanks especially fitted for this purpose.

ADVANTAGES OF OIL FIRING

With coal fired boilers there is always a considerable loss of steam on every watch through the burning down and cleaning of the fires. In the *Aquitania*, assuming 28 fires are cleaned every watch, nearly 8,000 horsepower is lost every four hours. With oil firing this loss is eliminated and constant steam pressure can be kept up, thus improving the speed of the vessel and the regularity of her service. Furthermore, owing to the fact that the temperature of the boilers can be maintained practically constant, the bill for boiler repairs will be materially reduced. With oil fuel it will be possible to bunker the vessel in about six hours without noise or dirt. The boiler room force will also work under incomparably better conditions in the stoke-hold and they will also gain in that special attention has been given to their accommodations. The rooms allotted to them form a new standard of comfort, cabins containing two, three or four berths each having been provided for each boiler room force.

PASSENGER ACCOMMODATIONS IMPROVED

Many improvements have been made in the passenger accommodations during the reconditioning of the vessel, among which the following are noticeable: On *D* deck, in the reception room opposite the restaurant, a bank and inquiry office, or information bureau have been installed. To the swimming pool and gymnasium have been added a large sun bath room. The staterooms on the boat deck have been converted into one-berth rooms, each fitted with a bed and settee. The whole of *C* deck amidships has been rebuilt, the staterooms having been greatly enlarged, reducing the number to 32 rooms. Many of these staterooms now have private dressing rooms.

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Here and There in the Shipping World

BY "OLD SCOTCH"

ONE of America's greatest shipbuilders told me several years ago that our husky cousin across the seas did not care such a great deal who built, owned and operated ships, so long as the "Tight Little Isle" could control the insurance. I did not take his remark seriously at the time, but from some of the cablegrams with London date marks which have been published recently, it seems that my shipbuilding friend was not so far off in his assertion as appeared at the time. When the threats that Lloyd's underwriters would positively refuse hereafter to assume any risks on American ships became widely circulated, they might have occasioned some alarm among the seafaring men of southern Indiana, but so far as I could judge from the faces of certain American marine underwriters whom I met at the time the threats were first hurled at us, it appeared that they were more amused than horrified. As a matter of fact, they *had* received cable advices from London underwriters discontinuing American business. In about three or four days, as the bluff did not seem to work at all, further cable advices were received stating that after mature consideration, etc., etc., American business in London would be resumed.

It was not the Jones bill, as popularly supposed, which put the English underwriters in such a spiteful frame of mind, but a piece of legislation enacted by the New York State Legislature previous to its recent adjournment, which required all foreign insurance companies admitted to do business in New York to file a statement of all American business done either here or at the home office, and pay taxes accordingly. Heretofore they have sidestepped much of the taxation which American companies have had to pay on similar business and hence have had a very decided advantage over domestic companies.

Insurance Syndicates Formed

Close on the heels of the London "strike" against America came the official announcement from the Shipping Board at Washington of the final signing of the contracts with the syndicates formed of all American marine insurance companies for taking over the insurance of all Shipping Board vessels and for underwriting the greater part of the risks on privately owned American merchant vessels. Syndicate "A" of this system is an underwriters' surveying organization to do for American insurance underwriters practically the same thing that the London Salvage Association does for English companies. This syndicate will be supervized by Charles R. Page, a former member of the Shipping Board, and more recently treasurer of the Atlantic, Gulf and West Indies Steamship Company. Mr. Page was for many years an official in the Firemen's Fund Insurance Company at San Francisco and is thoroughly competent to undertake the management of this important organization. Syndicates "B" and "C" are now in operation, and it looks as though for the first time in many years the bulk of the insurance on American vessels and cargoes will be written by American companies and the greater part of the $250,000,000 heretofore paid to foreigners annually for this purpose will be kept at home where it belongs. From the vigorous protests now being put up by several of our foreign maritime rivals, it looks very much as if the Jones bill is in reality what it was designed to be—a measure to encourage American shipping.

Shipping Developments Waiting for Shipping Board Appointments

At this writing, July 12, no action has been taken towards appointing the new Shipping Board provided by the Jones bill. As a result, shipping matters of all knds seem to have reached a standstill. So much depends upon the proper functioning of this new board that it is the uppermost wish in the minds of all persons interested in our new merchant marine that quick action be taken in making these appointments. Rumors as to the new personnel of this very important body are very numerous. Almost everybody who owns a yachting cap or who has been dubbed a "captain" is included among the possibilities for selection—that is, if we believe all the "inside dope" that is being handed out in shipping circles. It is but fair to assume that among so many aspirants, now that the salaries have been made somewhat commensurate with the duties to be performed, there should be no great difficulty in selecting commissioners who will measure up to the requirements. Let us fervently hope so, at least.

Disposition of the Leviathan an Important Problem

The disposition of the world's largest ship, the *Leviathan,* is one of the important matters awaiting the decision of this new board. When the bids for the purchase of this giantess were opened but one was received, and that in the sum of $3,000,000, with a request that if it be accepted the Government should make the purchaser a loan of $6,000,000 for reconditioning purposes and at the same time give the vessel free dockage during the extended period when the alterations would be made. As this sum is considerably less than the International Mercantile Marine bid for this craft, and as even that sum was considered grossly inadequate by the widespread publicity propaganda aimed against the sale of this fine vessel, it looks as if the board could not consistently accept the latest proposal. While $3,000,000 looks like a mere pittance for a ship which it is probable could not be reproduced under existing conditions for less than $25,000,000, there are attendant circumstances which, when taken into consideration, do not make that sum look so ridiculous.

The first of these is that ships of such herculean proportions and fast speed have never been looked upon as money makers, except possibly when considered as good advertising for the lines to which they belong. It will take a vast sum, estimated by some competent authorities as high as $10,000,000, to place her in first class condition for passenger service. Added to that, the vessel is now over six years old, and when her alterations are completed she will be at least seven years old. To the ordinary rules for depreciation, which would deduct considerable from her value, the fact that for over three years of her life she was tied up unused and not placed in a dry dock for painting her bottom must be given added consideration in appraising her present worth. In the more or less polluted waters surrounding Hoboken piers it is a safe gamble that her underwater plating must have deteriorated more than would ordinarily happen. Such a large vessel can only be used in one trade, and that is the North Atlantic passenger service, as nowhere else is there sufficient travel to promise full cabins, without which the loss would be tremendous. Little wonder, then, that only one bid was received, and it is not many organizations which would

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have the nerve even to undertake the operation of such a vessel.

The most likely outcome therefore is that the Government will retain ownership of this, the largest vessel in the world. We, as Americans, like to boast of the largest of everything. Let us therefore retain this great ship as a souvenir of the world's greatest war, but by all means let us have her operated by some private organization. Capital cost and depreciation are the largest items in ship operation, and the Government can well assume these. In the meantime the revenue from this ship will keep her up in good shape and make it profitable to a private organization to operate her. For transport purposes in time of war she is a most valuable ship, and her continuance in Government ownership will make her immediately available as a war-time asset in preparedness. A ship such as she is, 927.6 feet long, 100 feet beam, 54,292 gross tonnage and 90,000 horsepower, will not very soon be exceeded in dimensions, from the present outlook, so that for some years, at least, we can regale ourselves that this, the greatest government on earth, is in possession of the world's greatest ship.

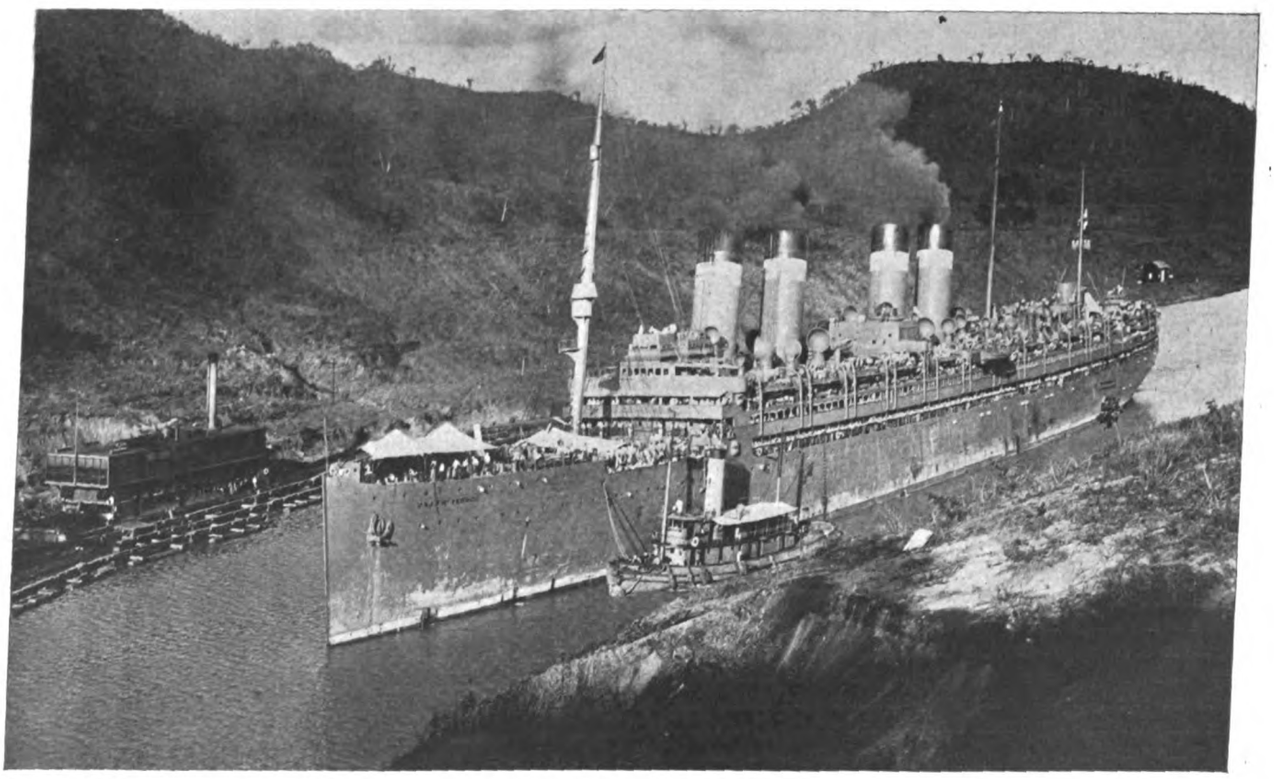
PROSPECTIVE SHIPBUILDING CONTRACTS

The dearth of new ship orders still continues, owing to the lack of a Shipping Board and to general uncertainties in the financial world. A clearing up of these conditions and the result of the forthcoming election settled will undoubtedly bring out a number of orders for new ships of special types. Among these are at least six new coastwise passenger ships about evenly distributed in number among the Admiral Line on the Pacific coast and the Red D Line and Porto Rico Line on this coast. Plans for those new craft are rapidly approaching completion. Undoubtedly some large motorships will soon be undertaken, as the prevailing prices of both coal and fuel oil make it economically imperative that we provide ourselves with ships that will use the smallest amounts of fuel for propulsion.

Pacific coast shipping people have been much perturbed of late at the threats of withdrawal from their ports made by certain foreign steamship lines, who took umbrage over the preferential rail rates authorized in the Jones bill on passengers and freight carried by American ships leaving our ports. They thought that they could circumvent this discrimination in favor of American bottoms by operating their vessels in the Pacific trade from Vancouver or other Canadian ports. Fortunately, the provisions of the Esch-Cummins transportation act recently enacted furnish the means for preventing such action on the part of our rivals, and Admiral Benson, the chairman of the Shipping Board, has made that fact known in unmistakable terms.

BOTH POLITICAL PARTIES PLEDGE SUPPORT OF THE MERCHANT MARINE

It is interesting to note that the platforms of both the great political parties recently adopted in the national conventions contain planks pledging each to the upbuilding and maintenance of the merchant marine. One of the most encouraging things in connection with our national efforts towards the rehabilitation of shipping is that it has been free from partisan rancor. Each party, of course, claims originality of the idea, but as each has demonstrated its sincerity in the support of all measures looking towards the best interests of our maritime affairs, it makes but little difference to which party first honors belong. Let us conclude, therefore, that the movement is backed by the entire American people and that, in consequence, we are bound to succeed in our endeavor.



United States Army Transport *Mount Vernon* (formerly the North German Lloyd Liner *Kronprinzessin Cecilie*) Passing Through the Panama Canal on May 25, Bound from Vladivostock to Hamburg, via San Francisco and Norfolk. Except for the British Battle Cruiser *Renown*, This is the Longest Vessel to Navigate the Panama Canal

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Shipbuilding Prospects in Russia

Russian Merchant Marine Practically Non-Existent—Material Resources and Shipbuilding Facilities of the Country

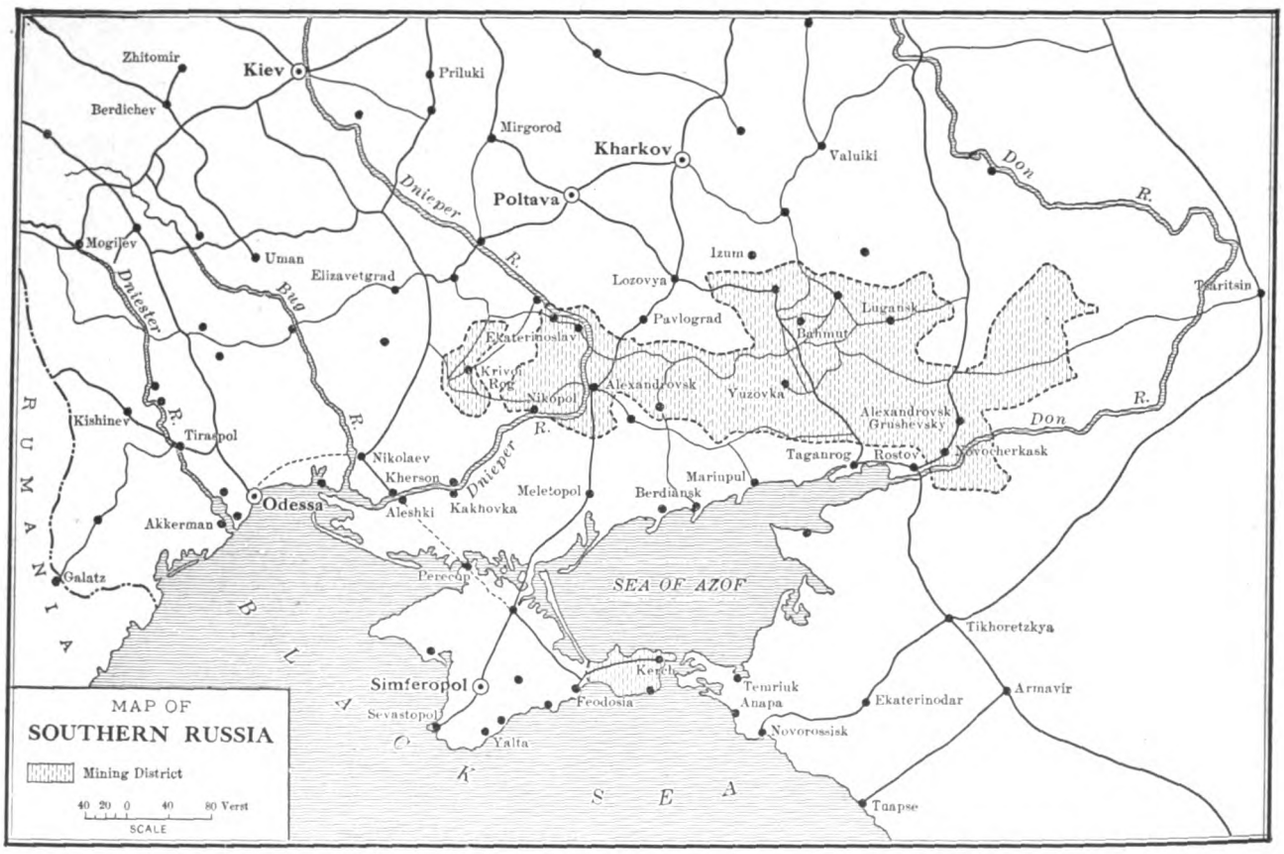
BY N. SETCHKIN*

DURING the war with Germany, Russia, on account of the difficulties of proper communication with the western allies, was unable to fulfill her tremendous national and military requirements with her own poorly organized industrial system. In spite of her very rich national resources, an economical crisis developed, and it was with difficulty that she recovered from her industrial shortcomings and consequent lack of technical equipment for the armies. As a matter of fact, this was accomplished only after she had suffered collosal losses of men at the front and by a gigantic overload through the use of poor mechanical equipment at the various shops. Social experiments of the Bolsheviki with nationalization of Russian industry, as well as the long continued blockade by the Allies, have brought Russia to a state of economical insolvency.

The majority of the works were forced to terminate operations, while the rest were not able to give one-tenth of their former production on account of the shortage of fuel and raw material, scarcity of machines and tools, as well as the lack of both organization and discipline in the shops resulting from the general state of civil war. Certainly this state of affairs cannot long continue. The cessation of naturally thriving industries cannot forestall the ever-increasing needs of a population requiring clothes, shoes, foodstuffs, machines, etc., and as soon as the blockade is lifted and trade with the rest of the world is resumed, Russian industry will immediately be restored.

The main problems for any Russian government, either democratic or soviet, will be the restoration of both interior and exterior transportation. According to recent information from Russia, a large army of labor specialists has been involuntarily transferred from the Red army to the water and railways for the purpose of putting the transportation machinery in order. New shipbuilding programmes are also mentioned for the river systems. Russia possesses comparatively good facilities of inland waterways on account of her large number of navigable rivers, which can be adequately utilized for the transportation of goods to and from the sea coast.

The next problem for the Russian government will be the re-establishment of the exterior transport system, i. e., the Russian merchant marine, which, as shown in Table I, was infinitely small. For instance, in 1914 Russia had only 600,000 gross tons of merchant shipping, which is equivalent to only 1.1 percent of the world tonnage, and she annually paid abroad $60,000,000 (£12,300,000) for freight alone. But at the present time the Russian



Map of Southern Russia, Showing Mining District and Principal Seaports

* Russian marine engineer.

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TABLE I.—GROSS TONNAGE OF MERCHANT FLEETS OF VARIOUS COUNTRIES OF THE WORLD, 1914-1919, AND TOTAL LOSSES IN UNITS OF ONE THOUSAND GROSS TONS

	Countries	1914	Percent of World Tonnage	1919	Percent of World Tonnage	Regain + or Losses —	Percent of Tonnage
1	United Kingdom	19,524	43.0	17,208	36.0	—2,316	—11.9
2	United States	2,027	4.5	9,773	20.4	+7,746	+382.0
3	Germany	5,135	11.3	3,247	6.8	—1,888	—36.8
4	Japan	1,708	3.8	2,327	4.9	+619	+36.3
5	France	1,922	4.2	1,962	4.1	+40	+2.1
6	Norway	1,957	4.3	1,597	3.3	—360	—18.4
7	Holland	1,472	3.2	1,574	3.3	+102	+6.9
8	Italy	1,430	3.2	1,258	2.6	—172	—12.0
9	Sweden	1,015	2.2	917	1.9	—98	—9.6
10	Austria-Hungary	1,052	2.3	713	1.5	—339	—32.2
11	Spain	884	2.0	709	1.5	—175	—19.8
12	Denmark	770	1.7	631	1.3	—139	—18.0
13	Russia	498	1.1	541	1.1	+43	+8.6
14	Greece	821	1.8	291	0.6	—530	—64.5
	Other Countries	5,189	11.4	5,149	10.7	—40	—0.8
	World Tonnage	45,404	100.0	47,897	100.0	+2,493	+5.5

merchant marine practically does not exist because a great number of ships were taken over by the Great Powers since the Bolshevist revolution broke out.

As this war produced economical crises throughout all countries, the world tonnage for a long time will be unable to supply Russia on such a large scale as would be necessary for the immediate restoration of Russian trade and industry, which has a great influence on the lingering process of strengthening the Russian state. That is why it would be quite plausible to expect the inauguration of a large shipbuilding programme in addition to the construction of river craft.

Russia's Natural Resources

Russia possesses rich natural resources necessary for the development of its own shipbuilding, as can be seen from Table II, where is shown the coal and iron ore resources and the production and output in the principal countries. These figures are taken from data of the International Geological Congress of 1910 and 1913 (The Coal and Iron Ore Resources of the World) and from "The Mineral Industry," by G. A. Roush. According to this table Russia ranks third in the world coal resources, but, compared with other countries, the utilization of these resources was very poorly developed, and in regard to actual coal output Russia ranked sixth. Defective mechanical equipment and improper organization were largely responsible for the low per capita production. Professor Goldenstein in his book "Russia and Her Economic Past and Future" gives the following figures:

	Metric Tons
United Kingdom	6.0
United States	5.1
Germany	3.8
Belgium	3.0
France	1.0
Austria Hungary	1.0
Russia	0.2

Possibly as soon as Russia improves her mining equipment and organization, production will be increased on a large scale. In respect to iron ore deposits Russia ranked sixth, but it is necessary to point out that no extensive research was carried out before 1913. Later very large deposits were found in the Kertch district (Southern Russia) estimated at approximately 1,000,000,000 metric tons.

In addition to large amounts of coal and iron, Russia possesses a big reserve of copper, manganese, lead, silver, etc. In the production of copper Russia had in 1913 second place in the world production (42,970 metric tons), and in the production of manganese ore first place (1,171,000 metric tons).

During many years before the war only Russia's own

TABLE II.—NATIONAL COAL AND IRON RESOURCES OF VARIOUS COUNTRIES AND THEIR PRODUCTION DURING 1913 AND 1916

	Countries	Coal					Iron Ore		Pig Iron	
		National Reserve (Estimated)	Percent of World Reserves	Output During 1913	Percent of World Output	Output During 1916	National Reserve Estimated	Percent of World Reserves	Production 1913	Percent of World Product
		Mill. Tons.	Percent	Mill. Tons.	Percent	Mill. Tons.	Mill. Tons.	Percent	Mill. Tons.	Percent
1	United States	3,838,652	51.85	570	38.6	597	7,500	38.4	31.48	39.7
2	Germany	423,356	5.73	305	20.6	—	3,607	18.4	19.29	24.3
3	Russia	233,997	3.16	37	2.5	29	864	4.4	4.55	5.7
4	United Kingdom	189,535	2.57	322	21.8	287	1,300	6.7	10.48	13.2
5	France	17,585	0.24	45	3.0	22	3,300	16.9	5.31	6.7
6	Belgium	11,000	0.15	25	1.7	20	—	—	2.49	3.1
7	Austria Hungary	55,393	0.75	59	4.0	51	283	1.5	2.37	3.0
8	Sweden	114	—	—	—	—	1,158	5.9	0.58	0.7
9	Other Countries	2,627,921	35.55	115	7.8	—	1,520	7.8	2.85	3.6
	World Total	7,397,553	100.00	1478	100.0	—	19,532	100.0	79.40	100.0

resources have been utilized for the building of her warships.

Location of Russian Shipyards

The majority of the shipyards are located in Northern Russia, where there are, for instance; the Admiralty Shipyard, Baltic Shipbuilding and Engineering Works, Pootilof Works, Nevsky Works, Russo-Baltic Shipbuilding Company and Cryton Shipbuilding Company. At that time the advantages of Southern Russia could not be used for the development of shipbuilding on account of the lack of free passage from the Black Sea. That is why only two shipbuilding concerns, the Russian Shipbuilding Company and the Franco-Russian Shipyard are located on the River Bug about 40 miles from actual Black Sea water. These two yards were sufficient for building the required number of warships for the Black Sea navy.

The mouths of both rivers, Bug and Dniepr (see map of Southern Russia), are really the best places for shipbuilding in Southern Russia, because, in the first place, climatical conditions allow shipbuilding to be carried on about eleven months of the year, and, in the second place, these two places are located very near to the coal and iron mining districts, to which they are connected by railroads and waterways (the river Dniepr and the Black Sea and Asov Sea).

The river Dniepr is deep enough for navigation by steamboats up to the town of Alexandrovsk (about 150 miles); further up to the town of Ekaterinoslov many rapids interrupt the direct line of transportation. Before the war the Russian Ministry of Wars and Communication had plans to construct in this part of the river a dam and locks with the utilization of the water power of the river. According to this plan a water power station developing about 750,000-1,000,000 horsepower will be installed, with a small steam power station in reserve to take care of the low water period (2-2½ months of the year), when the power of the water power station is only about 200,000 horsepower. For this steam power plant scrap coal may be used which is not available for transportation to other parts of Russia. This cheap energy is intended to be supplied to all works and mines of this district, even to the shipyards.

Other lines of transportation from the mining district may be kept up by coasters going throughout Black Sea to Asov seaports such as Berdiansk, Mariupol and Taganrog, which are connected by railroads to the mines.

The Sebastopol Bay, as well as Kertch Bay, may also be successfully used for southern shipbuilding, but the

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Asov Sea is not deep enough for ocean-going ships and its coast would be very unsuitable for such a plant.

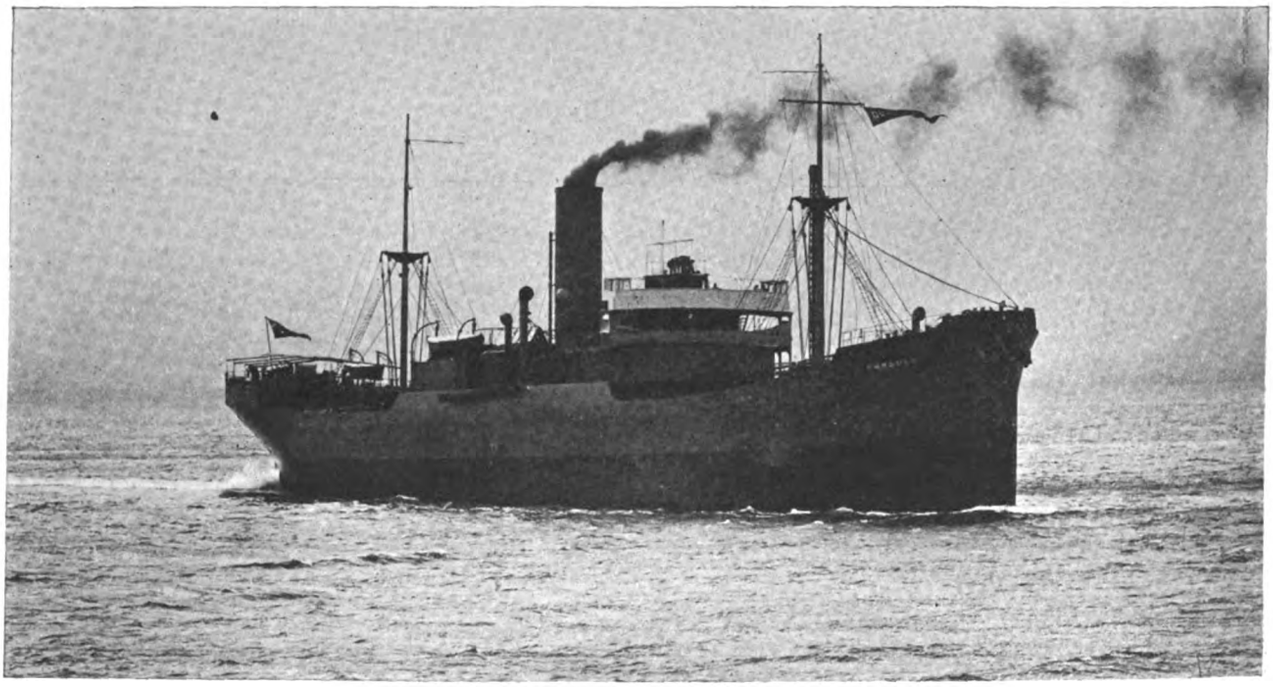
Practically all the Russian merchant marine has been built in foreign yards because without government protection the Russian yards were unable to withstand the competition of the foreign shipbuilding yards due mainly to lower costs and shorter time of delivery. But the Government at that time did not recognize the importance of this issue regarding Russian trade and industry and refused to give sufficient protection except in the case of building warships.

In 1913 and 1914 a company of Russian banks and metallurgical firms decided to take advantage of the excellent climatic conditions of the Black Sea, together with the neighboring centers of the metallurgical and coal industries, for the establishment of a shipbuilding plant in the south. The new company discovered that the time required for building Russian ships depended mainly upon the great delay experienced in procuring steel from the rolling mills, which were not accustomed to supplying the needs of shipbuilding concerns. On this account the new company decided to build simultaneously its own steel works, which could procure iron ore from its own mines and produce steel to meet the requirements of its own shipyard. Such an organization would greatly reduce the cost and time of building ships. Two concerns of this type were to be established in the near future, one on the river Dniepr, near the town of Kherson, and the other near the town of Kertch on Kertch Straits. According to the terms proposed by this company, construction of this plant was to be started within one year after the signing of the peace treaty and the expenditure on the plant in the first three years of development was to be not less than $1,300,000 (£267,000). These plans, however, did not materialize and were given up on account of the revolution.

At the present time Russian capital and industry have been harassed to such an extent that this plan would not be feasible in the near future without outside support. This problem of Rusian shipbuilding is so vitally important for Russian trade and industry, as well as for other countries which are desirous of obtaining grain and raw materials from Russia, that it is necessary for either government to take a hand in the settlement of this issue. However, neither will give liberal concessions to foreign companies for the development of the natural resources or for Russian shipbuilding.

German industrial interests displayed a long time ago great interest in the natural resources of the southern part of Russia, and during the occupation by the German army efforts were made to increase the production of these mines for their own uses. This interest has continued up to the present time, and they will continue to attempt to control the southern industrial business if the allied countries do not regard them seriously. Taking into consideration the huge success of American shipbuilding during recent years, it is evident that America could be a great competitor to any other country in the solution of this question because it would be easy for her to remove to Russia complete equipment of many shipbuilding plants which are now shut down due to the cancellation of contracts.

Nevertheless, it is certain that as soon as the blockade is removed and commercial relations are restored with the rest of the world, Russia will start to build her own merchant marine in order to attain the position among the sea powers corresponding to her rich natural resources and the requirements of her population and industry.



Australian Steamship *Dundula* on her Trial Trip

Progress of Shipbuilding in Australia

THE steamship *Dundula*, the fifth vessel to be completed under the Australian Commonwealth shipbuilding programme, ran satisfactory trials in Port Philip Bay, Victoria, on April 22. The vessel has a length of 341 feet, breadth 48 feet and a depth, molded, of 26 feet 1 inch. She is built on the Isherwood system of longitudinal framing, of the single deck type, with poop, bridge and forecastle, and is classed 100 A-1 at Lloyd's. She has exceptionally large hatches and ample cargo handling

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equipment consisting of eleven winches and eleven derricks, including one 20-ton derrick.

The captain and officers are berthed amidships, the engineers being on the bridge alongside the engine casings. The crew is berthed in the poop. All accommodations are ample in size with separate mess rooms for the firemen and sailors, as well as baths and wash rooms.

The vessel will carry 5,600 tons deadweight on 21 feet 9 inches draft and was built at the Cockatoo Island Dockyard, whence she was towed to Williamstown for the installation of her engines, which were manufactured and installed by Messrs. Thompson & Company, of Castlemaine (Vic.).

The machinery consists of triple expansion engines with cylinders 25 inches, 41 inches and 68 inches diameter by 45 inches stroke, and three Babcock & Wilcox watertube boilers of 180 pounds pressure.

The *Dilga*, the third of the contract for six ships at Walsh Island Shipyard, has been completed and handed over to the Commonwealth authorities. On April 28 she steamed to Sydney, and on the next day was docked at Cockatoo Island for cleaning and painting. On the 30th her compasses were adjusted in Sydney harbor, and she steamed to Newcastle the same day, when speed trials were carried out, the vessel averaging 12.84 knots during three hours' continuous steaming. Turning trials were also successfully carried out.

China's Waterways*

BY A. H. HALLAM†

ONE often hears industrial China spoken of, but few people realize from a marine standpoint the vast possibilities that exist for the development of the thousands of miles of waterways that intersect this large continent and the facilities for trading that would exist by quicker and more efficient transport once these rivers and canals are opened up by the use of steam and motor driven vessels.

The present method, with but few exceptions, is by the use of man power on shallow draft wooden boats averaging 60 feet long and 12 feet wide. Two long oars called "Ulohs" working on metal mushroom pins at the stern, one on each side, propel these vessels, each manned by four Chinese, male or female. They give these oars a peculiar twist in operation, which compares with the movements of a steam driven propeller. Their speed under normal conditions is about 15 miles per day.

They also operate similar boats with a flat bottom, fitted with a stern wheel made entirely of wood, which is made to revolve by a number of Chinese stepping on wood blocks attached to the sides of the axle turning the wheel —on the treadmill principle.

This particular class of vessel is principally used on shallow draft rivers and canals, and many are noticed daily wending their way from Ichang up the gorges to Chun-King, a somewhat dangerous trip to make on account of the strong currents. The river between these two places is barely 90 yards wide, with very high mountains on either side. To give some idea as to the strong current here, it is interesting to note that it takes 10 to 12 days to reach Chun-King, but only 2 days to return from there to Ichang.

Recently steel shallow draft steamboats of the stern wheel type have been operated on this river with success, and doubtless as time goes on the old-fashioned boat will disappear.

In wooden boats no metal of any description is used in their manufacture, even the nails being of wood. Every boat built is constructed with watertight compartments down to the small "Sampans" carrying one or two passengers.

On the Yang-tze-Kiang river, as far as Hankow, large commodious river steamers operate daily from Shanghai. They are somewhat similar in appearance to vessels used on the Hudson.

There is also a large coast service of small but well-

Fig. 1.—A Modern Passenger Boat on Canal near Pin-Kow

equipped steamers owned and operated by foreign and Chinese companies.

The Chinese as sailors and navigators are good, although their navigating instruments are home-made and crude. They venture to sea on long voyages on their large sea-going wooden junks. These trips are sometimes two or three months in duration. Their large bamboo masts slant in the opposite direction to ours—that is, at a forward angle of about 30 degrees forward instead of having a rake aft. The sails are fastened to long bamboos in the shape of blinds and are easily hauled up or stowed and reefed. The stern of these boats is built up very high in comparison to the bow and gives them the appearance of the ancient "galeon." There are hundreds of thousands of these junks sailing in Chinese waters, and

Fig. 2.—Looking Over Chun-King River. This Photograph Gives an Excellent View of this River's Boat Population

not a single metal nail is used throughout their entire construction.

Such a boat has a large population, at times running into three generations, as it is the custom in China for the children to care for their parents in their old age. Most of these people are born afloat and will die without ever knowing what it means to live on shore. While civilization has made such progress everywhere else, it touches China very slowly, and present customs, most of them, in many instances were in vogue 2,000 years ago.

* From *The Compass*
† General manager of Vacuum Oil Company at Shanghai, China.

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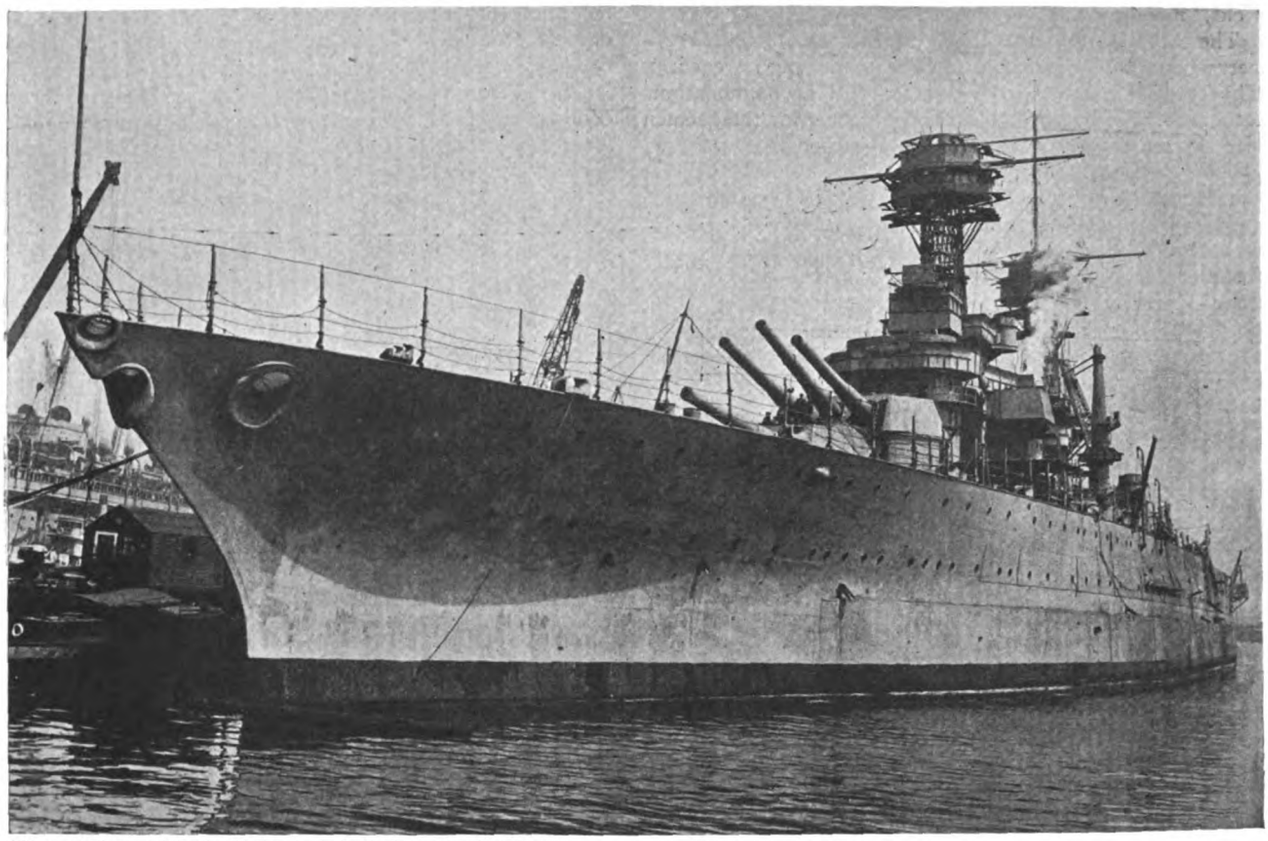

(Photograph copyright by Underwood & Underwood, New York)

United States Battleship *Tennessee*, Recently Commissioned at New York Navy Yard

The United States Battleship Tennessee

BY JAMES L. BATES

The United States battleship Tennessee, which went into commission on June 3, is the most powerful fighting vessel in the world today. She is 625 feet long, has a beam of 97 feet 3½ inches, and displaces 32,300 tons. Her main battery consists of twelve 14-inch guns, and she is protected by a heavy belt of armor. She is electrically propelled, her main engines consisting of two Westinghouse turbine generators, rated at 15,000 kilowatts each, and each of her four propellers is driven by an 8,000-horsepower Westinghouse motor. Her maximum speed with full power is 21 knots.

THE United States battleship *Tennessee* just completed at the New York Navy Yard, Brooklyn, N. Y., was, with her sister ship, the *California*, authorized March 3, 1915. The limit of cost for "hull and machinery" was $11,250,000. Her keel was laid May 14, 1917, she was launched April 30, 1919, and her total time of building covered a period of thirty-seven months. During a portion of this time it was impossible to push her construction on account of the volume of other war work of greater urgency.

The principal dimensions of the new fighter are as follows:

Length on waterline	600 feet 0	inches
Beam on waterline	97 feet 3½	inches
Mean draft, designed normal condition	30 feet 3	inches
Normal displacement, designed	32,300	tons

The armament of the *Tennessee* consists of twelve 14-inch, 50-caliber guns mounted in turrets, two 21-inch submerged torpedo tubes, fourteen 5-inch, 51-caliber rapid fire guns, four 3-inch anti-aircraft guns, and miscellaneous small caliber guns for boats, saluting and landing, together with the usual machine guns and small arms.

The turrets are of the latest three-gun type, all on the center line, two forward and two aft, placed in vertical echelon. This arrangement is now standard and has been adopted for nearly all capital ships of recent design.

The 5-inch guns are mounted on the upper and superstructure decks. They are placed well inboard from the vessel's side so as to be as free of water as possible when being operated in a sea-way.

Protection

The protection is arranged in accordance with recent American practice. A wide armor belt of great thickness extends amidships in way of the magazine, machinery and control spaces. A heavy, though narrower, belt extends aft in way of the steering gear. Heavy thwartship armor is fitted at the forward and after termination of the wide belt and at the after end of the narrower belt.

The protection of turret guns and conning positions is

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very complete, both against direct hits and damage by fragments.

A heavy protective deck is fitted at the level of the top of the side belt, and a lighter splinter deck is worked a deck height below. These decks, together with longitudinal splinter bulkheads, have been so designed as to give excellent protection to the ship's vitals against the plunging fire to be anticipated in the long range actions of the present day.

A point of further interest in connection with the deck protection just noted is that it has been designed so as to form an effective part of the vessel's longitudinal girder and is of such thickness as to maintain adequate strength even after the structural strength deck next above has been entirely shot away. Such an arrangement of deck material also affords good protection against aerial attack, a matter of increasing importance at the present time.

ACCOMMODATIONS

The officers are quartered aft on the second and third decks. The crews are located amidships and forward on the main and second decks. The complement consists of 64 officers and 1,345 enlisted men and chief petty officers.

The vessels of the immediately preceding classes, the *Pennsylvania* and *New Mexico*, were designed for displacements of 31,400 and 32,000 tons respectively, although their lengths are the same as the *Tennessee* and their other dimensions do not differ materially from her's.

It will be seen from the foregoing that the *Tennessee* is of somewhat greater displacement than any other of the war vessels of the United States Navy now in commission.

CHARACTERISTICS

Above water the *Tennessee* is typical of recent United States naval design for capital ships. She has the clipper stem intended to facilitate the stowage and handling of her anchors. Her upper deck extends from the stem to abaft amidships, at which point the main deck becomes the weather and extends as such to the stern. The stern is of the usual cruiser type common to most large war vessels. Forward, above the waterline, the vessel has a pronounced flare right out to the upper deck edge. This flare is carried forward to the stem.

Below water the vessel's form differs little from those of her immediate predecessors. She has the usual hard bilged midship section with wall sides and nearly flat bottom, but she has no parallel middle body such as has been used sometimes. Her prismatic and block coefficients are moderate and well suited to the conditions imposed. She has full forefoot sections below water, but a moderate angle of entrance at the load waterline. Her cross-sections are relatively slack forward of her forward quarter point, giving noticeably hollow waterlines at and below half draft. In the vicinity of the forward quarter point the hard midship bilge begins to take form. Aft the cross-sections are much cut away at the lower waterline, but the load waterline is kept relatively full. The keel is worked straight from forefoot to within 56 feet of the after perpendicular. This feature, together with the docking keels fitted in the way of heavy concentrated weigths, insures safety and facility in docking. Short bilge keels are fitted forward and aft in the vicinity of the quarter points.

PROPELLING MACHINERY

The propelling machinery consists of two turbo generators and four main motors driving four propellers. The maximum horsepower of the main motors is somewhat over 28,000. Steam is generated by eight oil burning Babcock and Wilcox boilers, each located in its own compartment. The maximum designed speed is 21 knots and the cruising speed 10 knots.

Oil fuel is carried in bottom and side tanks, so disposed as to provide an efficient protection against fragmentation in the event of successful torpedo attack.

SPECIAL FEATURES

Particular attention has been given to the design and arrangement of conning positions and bridges in the light of the lessons of the recent war. This has resulted in the apparently cumbersome structure immediately aft turret No. 2.

Another feature given considerable prominence in recent United States naval design has been the ability of ship structures to withstand great hydrostatic pressure. The importance of this consideration has been emphasized repeatedly during the war, and the test heads to which the structure of the *Tennessee* has been subjected during construction represent a noteworthy advance over all our own previous practice.

The auxiliary machinery is in general electrical. This applies to turret turning gear, to elevating, ramming and shell hoisting gear, as well as to anchor handling, steering, boat and provision handling gear and ventilation. Oil burning ranges are used in the galleys, but the commissary appliances generally are electrical.

The following table places some of the leading characteristics of the *Tennessee* in comparison with those of certain battleships of Great Britain and Japan and with the United States battleship *Pennsylvania*:

	Pennsylvania	*Tennessee*	*Iron Duke*	*Royal Sovereign*	*Yamashiro*	*Ise*
Nationality	United States	United States	Great Britain	Great Britain	Japan	Japan
Length overall	608 feet	624 feet	622 feet 9 inches	624 feet 3 inches	630 feet	640 feet
Breadth, extreme	97 feet ½ inch	97 feet 3½ inches	90 feet 0 inches	88 feet 6 inches	94 feet	94 feet
Load draft	28 feet 10 inches	30 feet 3 inches	28 feet 0 inches	28 feet 6 inches	28 feet 6 inches	28 feet 4 inches
Displacement, tons	31,400	32,300	25,000	25,750	30,600	31,260
Fuel at load draft, tons	1,548	.....	900	900	1,500	900-1,000
Coal capacity, tons	.....	.....	3,250	.....	2,800	2,750
Oil capacity, tons	2,322	.....	1,050	3,400	800	850
Shaft horsepower	29,000	28,000	29,000	40,000	40,000	45,000
Corresponding speed, knots	21	21	21	23	22½	23
Armament	Twelve 14-inch Fourteen 5-inch Two 21-inch T.T.	Twelve 14-inch Fourteen 5-inch Two 21-inch T.T.	Ten 13.5-inch Twelve 6-inch Four 21-inch T.T.	Eight 15-inch Fourteen 6-inch Four 21-inch T.T.	Twelve 14-inch Sixteen 6-inch Six 21-inch T.T.	Twelve 14-inch Twenty 5½-inch Six 21-inch T.T.
Main battery location	Four 3-gun centerline turrets	Four 3-gun centerline turrets	Five 2-gun centerline turrets	Four 2-gun centerline turrets	Six 2-gun centerline turrets	Six 2-gun centerline turrets
Date of laying keel	October, 1913	May, 1917	January, 1912	January, 1914	December, 1913	May, 1915
Date of completion	June, 1916	June, 1920	March, 1914	May, 1916	April, 1917	December, 1917

An examination of the above table reveals the following points of interest:

Great Britain put her last battleship of the conventional type into service four years ago, and since that time has built only capital ships of great speed. Both the United States and Japan have continued building the moderate speed battleships.

The latest types of battleship built by both Great Britain and Japan show increases of speed over the 21 knots which has been practically standard for the United States battleships since the *Delaware* class.

Great Britain, in so far as battleships are concerned, has not reached the large displacements which the United States and Japan have adopted.

Great Britain places less displacement on a given length than either the United States or Japan.

(*Concluded on page 656.*)

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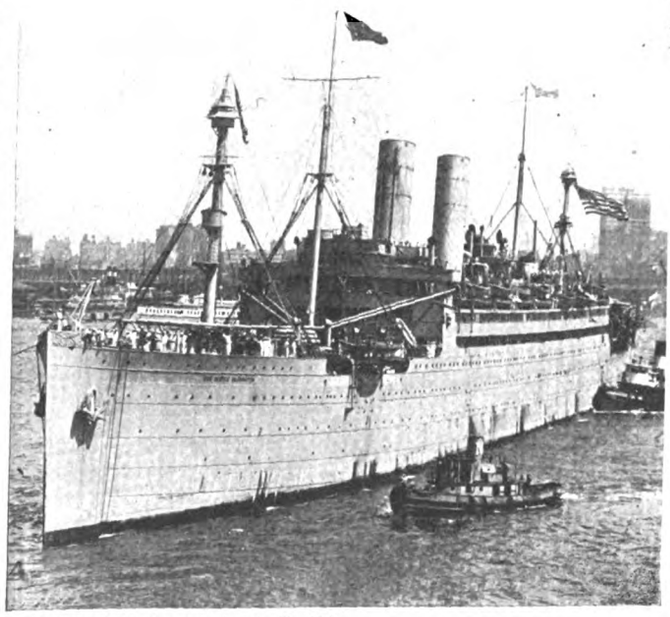
Famous Ships—The George Washington

BY CHARLES E. OLIVER

The problems of prompt transportation of troops after the United States entered the world war, and the seizure of the interned German liners for this purpose, have made the history of these ships of considerable interest, and among them none can have a greater interest in future marine annals than the historic and internationally famous ship which bore the President of the United States on his momentous errand at the closing of the great war.

DURING the early years of the present century up to the outbreak of the war in 1914, the Imperial German Government seems to have been actuated by the keenest ambition to cope with England so far as possible in the carrying trade of the world, and to this end encouraged in every way possible the construction of the wonderful masterpieces of the shipbuilding art carried out by the North German Lloyd and Hamburg-American companies. This resulted in such ships as the *Vaterland, Amerika, Kaiser Wilhelm II, Kronprincessen Cecilie* and others, as well as the building and improvement of great docks and piers in New York, Boston and other American ports. Another aim which Germany seems to have kept constantly in mind was the conciliation and good will of the United States, and the subject of this sketch was named in honor of Washington as a special compliment, being at the time of building the largest and most elaborately fitted ship ever built in Germany.



(Photograph by International, N. Y.)

The George *Washington*, With President Wilson on Board

The *George Washington* was built by the Vulcan Works, Stettin, Germany (Stettiner-Maschinenbau-Actien-Gesellschaft "Vulcan," Stettin-Bredow). The vessel was launched on November 10, 1908, and given her trial trip on June 2 of the year following. She made her maiden voyage June 12, 1909, her regular route being between Bremen and Hoboken, N. J.

The following dimensions, showing the size of this great ship, may be of interest:

Length overall	722 feet 5 inches
Length between perpendiculars	697 feet 6¼ inches
Length on waterline	700 feet 0 inches
Beam	78 feet 0 inches
Depth from upper saloon deck	54 feet 0 inches
Depth from awning deck	80 feet 0 inches
Draft	33 feet 0 inches
Displacement at above draft, tons	36,000
Horsepower	20,000
Speed, knots	18½
Revolutions per minute	83
Gross registered tonnage	25,570
Normal troop carrying capacity	5,175
Maximum persons carried on any single trip	7,121
Boat and life raft accommodations	9,128

She is a twin-screw passenger and freight steamer with a straight stem, semi-elliptical stern, two funnels and four pole masts. The hull, of steel with a double bottom for her entire length, is equipped with twelve watertight bulkheads, which divide the ship into thirteen watertight compartments. The screws are 21.33 feet in diameter and all her boilers are 15¾ feet in diameter.

When the United States entered the conflict, one of the first acts of war was to seize the interned German ships, among them the *George Washington*, then lying at her berth in New York harbor. Before it could be prevented it was found that the crews of several of these great ships, presumably acting under orders, had done serious damage to the engines by smashing parts of the high pressure cylinders in a way which the Germans supposed would make it impossible to replace or repair them for at least two years or for the duration of the war, thereby rendering the vessels useless either for transport or for other service.

On July 17, 1916, the *George Washington*, thus badly damaged, was towed from her berth in Hoboken, N. J., to the New York Navy Yard, under the orders of the United States Shipping Board, to see what could be done to repair the injuries to her engines. To the surprise of naval experts, and especially to the Germans themselves, American mechanical ingenuity was equal to the emergency, and by a process of electric welding of large steel castings the cylinders were completely repaired in a period of *three months.*

The trip which in the following year brought this ship into special prominence was the famous voyage which took the President and his party to Brest, France, soon after the signing of the armistice. On December 4, 1917, she steamed out of her berth in New York harbor under heavy naval convoy, with the battleships *Pennsylvania* and *Wyoming* leading under command of Admiral Mayo, together with the *Arkansas, Florida, Utah, Nevada, Oklahoma, New York, Texas* and *Arizona,* and amid the shrieking of innumerable whistles of every description and the greatest possible enthusiasm.

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The President occupied the suite de luxe on C deck, staterooms 65 and 66, and on the entire trip was extremely interested in everything that occurred on shipboard, seeming fully to enjoy the much-needed rest and recreation which the trip afforded. The ship was under command of Captain Edward McCauley, Jr.

After an interesting voyage, the ship approached the French coast, where she was met by French and American destroyers and numerous airplanes, arriving at Brest about three o'clock on the afternoon of December 13. On the 14th, ten of the battleships started for the return to New York, and on the 15th the *George Washington* herself left Brest, having 331 officers and full crew, and with 3,461 returning soldiers, and arrived in New York on December 23. Of the returning soldiers about one-half were members of the famous "Cyclone" Division from Indiana, Kentucky and West Virginia National Guard troops, of whom 968 were wounded.

The second trip with the President began on the morning of March 5, 1919, when again the *George Washington* slipped from her berth on the north side of Pier 4 into New York harbor, accompanied by six destroyers and the battleship *Montana* as convoy. On this trip she was under command of Captain W. J. Bernard, and carried a crew of some 1,100 men. As she poked her way out into the stream the great guns from the surrounding warships thundered forth the Presidential salute of 21 guns, and from hundreds of harbor craft of all kinds came whistles and tooting as she was escorted out by many air craft.

Since her previous trip the ship had been painted throughout, and she was now equipped with new high-powered wireless apparatus with a radius of 1,100 miles. This precluded the possibility of wireless isolation as had occurred during a period of her former trip, when with a wireless radius of only 300 miles the President had been for several days entirely out of communication with Washington or the world. By the new equipment he was in constant communication with the station at Brunswick, N. J., until they could pick up the Poldhu Station on the other side of the Eiffel Tower. Passing quarantine about 9:10 A. M., this second trip was uneventful, and with an average speed of some 16 knots she arrived in about eight days at Brest on Thursday evening, March 13, on a beautiful moonlight night. At 9:45 the President disembarked for his trip to Paris, where he arrived the following morning.

TROOPSHIP SERVICE

Beginning with her first trip on December 4, 1917, the *George Washington* made twenty-three round trips as a troopship between Hoboken, N. J., and Brest, France, up to the return from the first Presidential trip arriving at Hoboken on December 23, 1917.

At the present time she is undergoing extensive repairs at the Boston Navy Yard, preparatory to re-entering the passenger service. She is now under command of Captain William J. Ryan, and to him we offer our very best wishes in his future command of this interesting and splendid ship.

New Cunard Liner

Combination Type of Passenger and Freight Steamer for Transatlantic Service

WILLIAM BEARDMORE & COMPANY, LIMITED, recently launched from the Naval Construction Works, Dalmuir, the twin screw geared turbine steamer *Tyrrhenia*, which is being constructed for the Cunard Steamship Company, Limited, of Liverpool.

The *Tyrrhenia*, which is practically a sister ship to the *Cameronia*, which the Beardmore Company is now completing for the Anchor Line, Limited, has a cruiser stern, straight stem, one funnel and two pole masts.

PRINCIPAL DIMENSIONS

The principal dimensions of the vessel, which is of about 17,000 tons gross, are as follows:

Length overall	578 feet 6 inches
Length on load waterline	572 feet 6 inches
Length between perpendiculars	550 feet 0 inches
Breadth molded	70 feet 0 inches
Draft on load waterline	29 feet 0 inches
Depth molded to "C" deck	42 feet 9 inches
Depth from keel to boat deck	67 feet 9 inches

It is estimated that the vessel will be capable of carrying about 11,000 tons of deadweight at her designed draft of 29 feet.

GENERAL ARRANGEMENT

There are seven decks in all, namely, boat deck, A, B, C, D, E and F decks.

On A deck immediately under the boat deck are arranged the first class public rooms, consisting of lounge, smoking room, writing room, verandah café and gymnasium. These rooms are situated practically in the midship portion of the vessel and a little further aft are placed the second class lounge and second class smoking room. All these apartments are very spacious and will be handsomely furnished and decorated. On B and C decks, accommodation is provided for about 265 first class and 370 second class passengers in two- and four-berth staterooms fitted and furnished in every way to ensure the comfort of their occupants. A general room and a ladies' room for third class passengers are also provided on C deck.

On D deck amidships are placed the first and second class dining saloons with galleys, pantries, etc., between them. The first class saloon is capable of dining about 220 persons, and the second class about 300 persons at one time. Both of these apartments are very roomy and will be suitably furnished and decorated. At the forward and after ends of D deck sleeping accommodation is provided for third class passengers in two-, four- and six-berth cabins, and at the after end another general room and a smoking room for third class passengers are provided.

On E deck, practically amidships, are placed two large dining rooms for third class passengers capable of dining about 500 persons at one time, and in four other compartments on this deck sleeping accommodation is arranged for third class passengers in two-, four- and six-berth cabins, the total sleeping accommodation for this class being about 1,150 passengers.

MAIN PROPELLING MACHINERY

The machinery, which is supplied by the builders, consists of two sets of Brown-Curtis turbines, each set com-

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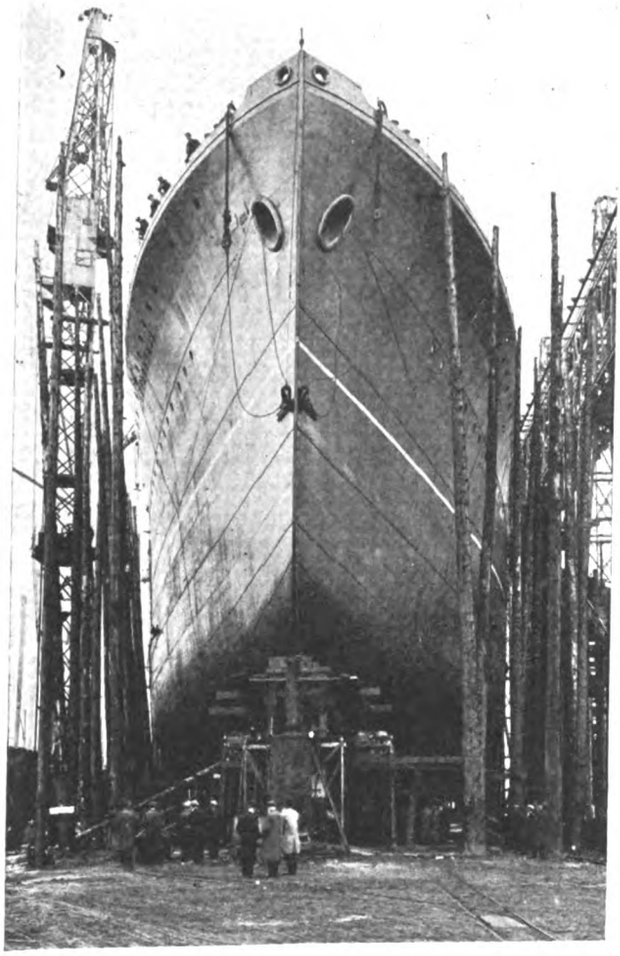


prising one high pressure, one intermediate pressure and one low pressure turbine. Astern turbines are incorporated in each intermediate pressure and low pressure casing. The turbines drive the propeller shafts through helical gearing of the double reduction type.

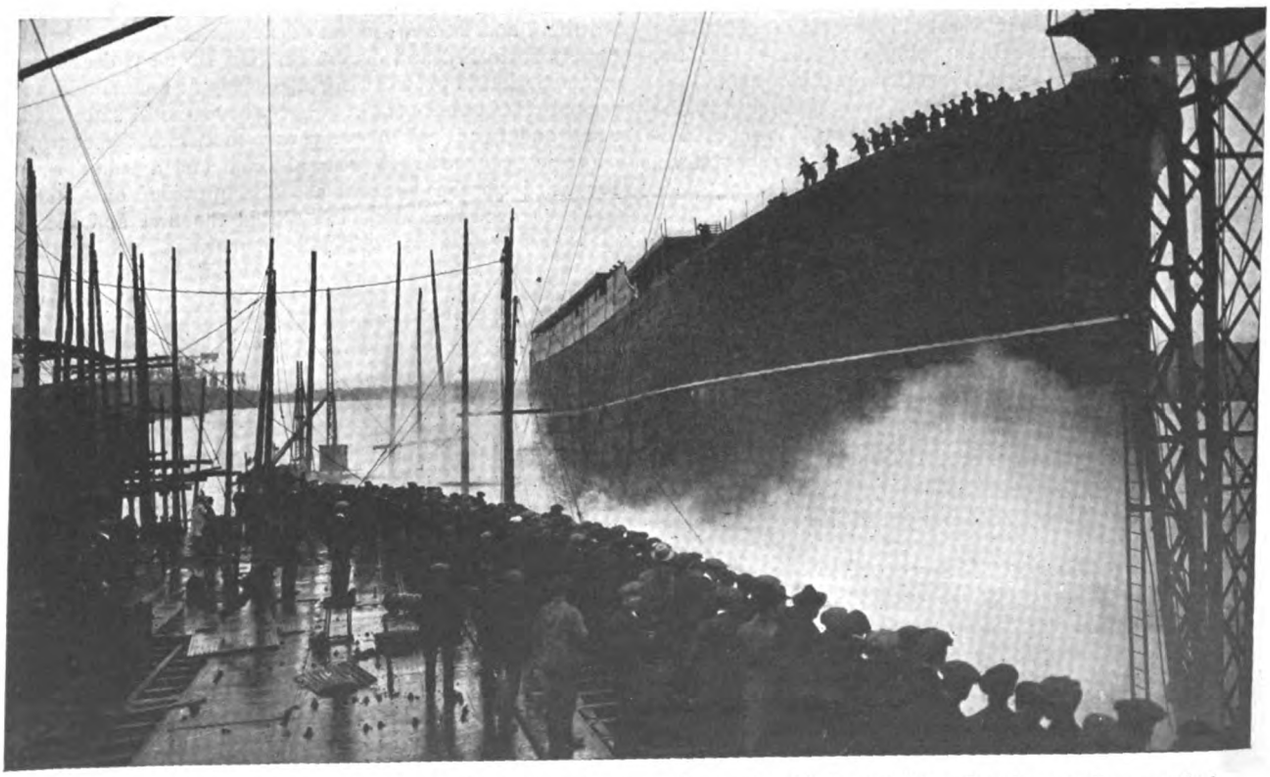
Steam is supplied by three double end and three single end boilers, the double end boilers being 22 feet 6 inches long and the single end boilers 11 feet 6 inches long, the diameter of all boilers being 17 feet 6 inches. Howden's forced draft and superheaters of the smoke pipe type are fitted to the boilers, which are designed to burn oil fuel, but which can be readily converted to burn coal.

The machinery is capable of developing 13,500 shaft horsepower, and it is estimated that the vessel will maintain on service in moderate weather a speed of 17 knots.

A feature which will no doubt be much appreciated by passengers is the substitution of electro-hydraulic deck machinery for steam driven machinery. The steering gear, cargo winches and the windlass are all of the electro-hydraulic type, thus ensuring a minimum of noise and vibration due to the working of these auxiliaries.

The vessel is subdivided so as to ensure that she will float with any two compartments flooded, and special fireproof bulkheads are arranged to prevent the spread of fire in case of a conflagration breaking out on board. She will be equipped in the most up-to-date manner as regards cooking arrangements, sanitary accommodation, ventilation, heating, hospitals, wireless telegraphy and boat and life-saving appliances, and the comfort of the officers and crew has been specially considered.

The *Tyrrhenia,* which was designed by the Cunard technical staff, of which Mr. Leonard Peskett is the naval architect, is being built under special survey and classed 100 A-1 at Lloyd's. The vessel is constructed to comply with the British and American authorities' regulations in all respects as a passenger vessel and to the full standard of The International Convention for the Safety of Life at Sea.



Views of the Launching of the New Cunard Liner *Tyrrhenia* at the Naval Construction Works of William Beardmore & Company, Ltd.

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New Graving Docks at Portsmouth, Va.

BY HARRISON S. TAFT*

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During the past three years a vast amount of information covering various phases of our merchant marine has been furnished the public in the way of statistics and illustrations of its new ships and the yards in which they were built. Little has been said, however, about the necessary adjuncts for the preservation of our new vessels—the ship repair yards and dry-docking facilities. At the Norfolk Navy Yard three concrete graving dry docks, built on the arch type of construction, have been completed in record time under conditions that have made the work a noteworthy engineering achievement. How this immense project was carried through to completion in thirty-seven and one-half months and the details of the work are told in this article.

WHILE a great many new dry docks have been built in this country during the past few years, most of them have been of the "cradle" and "floating" type construction. However, it is fitting to state that several dry docks of the graving type have likewise been constructed, of a size far beyond anything ever attempted in the other types of structures, three docks of the graving type having been but recently completed at the Norfolk Navy Yard. While wooden or granite-lined structures have hitherto been the standard type adopted in this country for graving docks, the three new dry docks at the Norfolk Navy Yard are concrete monolithic structures built on the arch principle and represent what is virtually a new development in graving dock structures.

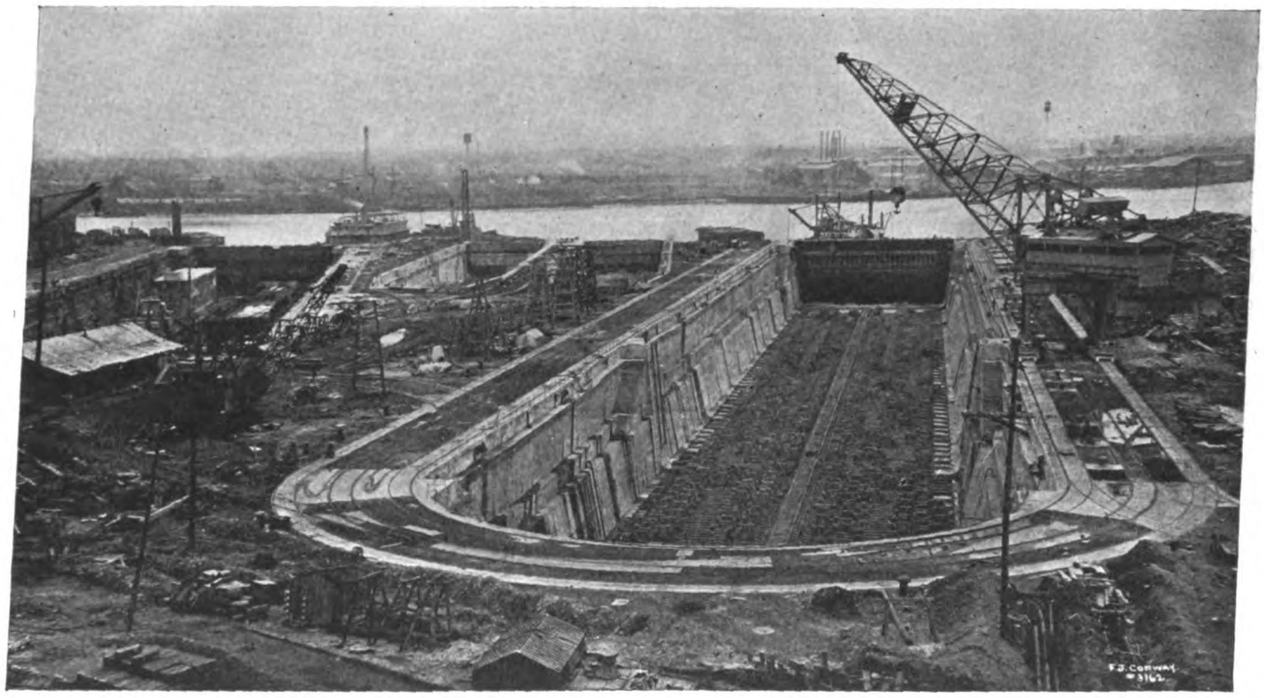

Fig. 1.—Dry Docks 4, 6 and 7, Taken from Top of Machinery Section of New Power House, Norfolk Navy Yard, During the Last Week of February, 1920

These docks were designed under the supervision of Rear Admiral F. R. Harris, U. S. N., and built by the George Leary Construction Company, George Leary, president; Fred H. Schonburg, vice-president; Harrison S. Taft and H. L. Mockemore, construction engineers

The Thousand-Foot Dry Dock

The most important of the three new dry docks recently built at Portsmouth, Va., is dock No. 4, designed by the Bureau of Yards and Docks, Navy Department, under the supervision of Rear Admiral F. R. Harris, along new and novel lines. This dry dock is without doubt the most complicated mass concrete structure ever built in this country. Measuring 1,000 feet in length from the outer caisson ring to the head wall of the dock, the dock has a width of 144 feet at its coping and a draft of 40 feet over the keel blocks at mean high tide. The height of the walls is 50½ feet. The minimum depth of the concrete floor is 20 feet. Around the top of the dock are three lines of standard gage track which afford access to all parts of the structure for the numerous yard cranes and for the new 75-ton crane built especially to serve this dock. A massive steel caisson closes the river entrance to the dock.

The flooding of the dock is accomplished by means of a large size tunnel built in the south wall, with numerous outlets through the wall into the dock proper as well as into the longitudinal drains built in the floor of the dock.

* General manager in charge of construction Dry Docks 4, 6 and 7, Norfolk Navy Yard, for the George Leary Construction Company, New York.

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The pumping plant consists of three Worthington electrically-driven, centrifugal pumps situated at the bottom of deep wells in the south wall of the structure and of two smaller drainage pumps placed in a deep sump near the main pumps. All of these pumps draw water from a large suction chamber built in the base of the south wall, the roof of which forms the foundation for the three main pumps. The water flows through the floor drains, which run longitudinally the length of the dock into this chamber. The outer part of the flooding tunnel acts as a discharge passage for the pumped water, heavy sluice gates being provided to control the flow of the water in flooding and pumping out the dock.

A complete system of fresh and salt water pipes, as well as an air line and electric lighting system, extends around the dock inside of a tunnel which is built in the upper section of the walls to provide for a proper handling of the necessary work when ships enter the dock for painting and overhauling. Various flights of stairs and an elevator were provided to afford ready access to all parts of the structure.

In all 625,000 cubic yards of earth were moved and some 184,000 cubic yards of concrete poured in executing the work on this dock.

Details of the Smaller Docks

Dry docks Nos. 6 and 7 are twin graving docks built for the Emergency Fleet Corporation. They are each 471 feet long with a maximum width and depth to suit the vessels of our new merchant marine. At their river entrances both docks have steel caissons which are interchangeable.

These docks are flooded through six 24-inch valves in each caisson and through a tunnel built in the division wall. The tunnel extends in beyond the inner caisson rings and empties into both docks. A sluice gate is provided at the outlet of the tunnel to each dock. The longitudinal drains in the floor of each of these two docks are connected by large separate tunnels which exit in the floor of dry dock No. 4 with the suction chamber of dry dock No. 4; thus the pumps of dry dock No. 4 are used to pump out all three docks.

Standard gage tracks extend along the entire length of the two outside walls of each dock, while down the division wall is a 16-foot gage crane track which connects with a similar gage track that extends throughout the dry dock section of the yard.

Construction of Dry Dock No. 4

The construction of dry dock No. 4 involved engineering and construction problems of great magnitude. The excavation was done in the dry by two Bucyrus draglines, part of the material being carried out to sea on scows, the rest being used for reclaiming swamp land within and near to the Navy Yard and also for backfilling the concrete walls. The depth of the excavation in general was 72 feet below the original ground level, with a maximum depth of 92 feet. With the exception of the pump well section of the dock, the bottom of the excavated hole was bowl shape, the sides having a slope of 1 on 1, giving a width of cut at the ground level of about 375 feet. The top material consisted of ordinary earth and beach sand, the rest of the excavation being of blue clay and marl, resulting in a most satisfactory foundation for the concrete structure to rest upon. As but little water was encountered during the progress of the work, the conditions were almost ideal for carrying the project through to a rapid and successful completion.

In building the concrete structure, numerous devices and methods were utilized to hasten the work to completion. The first necessary step was to devise a "standard mode," as it were, for the construction of the entire dock (considered as a unit) in all its varying features and then to design "the concrete forms" to suit "the mode" adopted.

Thus it was possible to carry on the work from day to day in accordance with an adopted plan of procedure and not by trying to work along without any definite idea as to what was really necessary and needed for a successful execution of the work. By this method of procedure the entire organization knew far in advance the exact solution to be used as the work progressed (that is, as far as the human mind could foresee) and it was constantly working along one definite line to accomplish one definite result. This permitted the work to be driven at high speed to a rapid and successful completion, as it was found necessary to make but few changes in the "plan of procedure," all of which was foreseen far enough ahead to be properly provided for, each in its turn.

"Form-Work" and Method of Pouring the Concrete

The "form-work" involved in building dry dock No. 4 was of a most complicated and stupendous nature and called for the use of a vast amount of lumber. The floor of the dock has a minimum depth of 20 feet and was formed in one lift, the length and width of the forms being such as coincided best with the different parts of the design. The side walls were divided up into lifts of various heights as best to preserve the solidity of the structure. Many of the lifts were 28 feet high. One was 41 feet high, but the climax was reached when a wall form 51 feet 6 inches high and 60 feet long, containing 2,000 cubic feet of concrete, was erected and successfully formed as a true monolith, no interruption in pouring the concrete being permitted throughout the seven consecutive days it took to fill the form. The interior of this form consisted of complicated water passages, pipes, stairways and electric ducts, as well as steel reinforcement and anchor bolts with a concrete beam system for the railroad tracks running along the top of its entire length. The successful execution of this particular feature of the work was pronounced by engineers to have been one of the most audacious and stupendous pieces of form-work in the annals of the Bureau of Yards and Docks.

The concrete was mixed at the "mixing plant," located at the waterfront, all material being delivered in barges or scows. Two 2-cubic-yard mixers were used, the concrete being transported from the mixer to the top of the excavation in hopper cars drawn by locomotives and in general sent down steel chutes into the concrete forms. To meet varying and local conditions it was necessary to resort to innumerable methods in transferring the concrete from the hopper cars to the form, the drag line excavator at times being pressed into service in performing the operation where no other more economical method could be devised.

To provide a proper resting place for ships when placed in the dock, over 850,000 board feet of oak was secured to the concrete floor of the structure in way of the centerline and bilge keel blocking.

After the initial flooding of the dock in the presence of a large party of distinguished naval officers and citizens, the earth dike across the water end was dredged out by one of the largest dipper dredges on the coast, the massive caisson floated into place, the dock pumped out and made ready for docking its first ship.

While the task set for the engineers and the working crew in the construction of dry dock No. 4 was vast and difficult, in comparison the building of dry docks Nos. 6 and 7 was exceedingly simple, the only difficult part being

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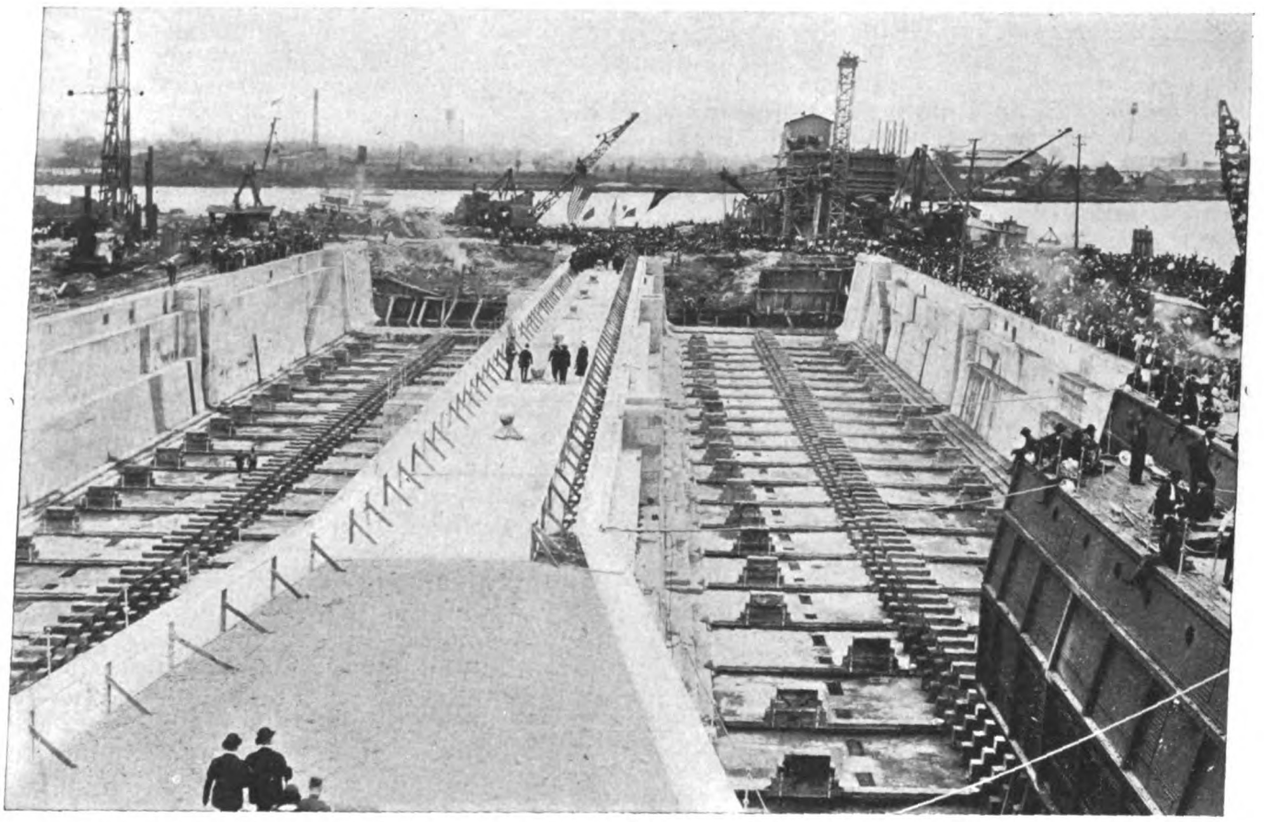

Fig. 2.—Dry Docks 6 and 7, from Top of Engineer's Office, Taken at Time of Dedication. Barley, Parsons & Klapp, Consulting Engineers

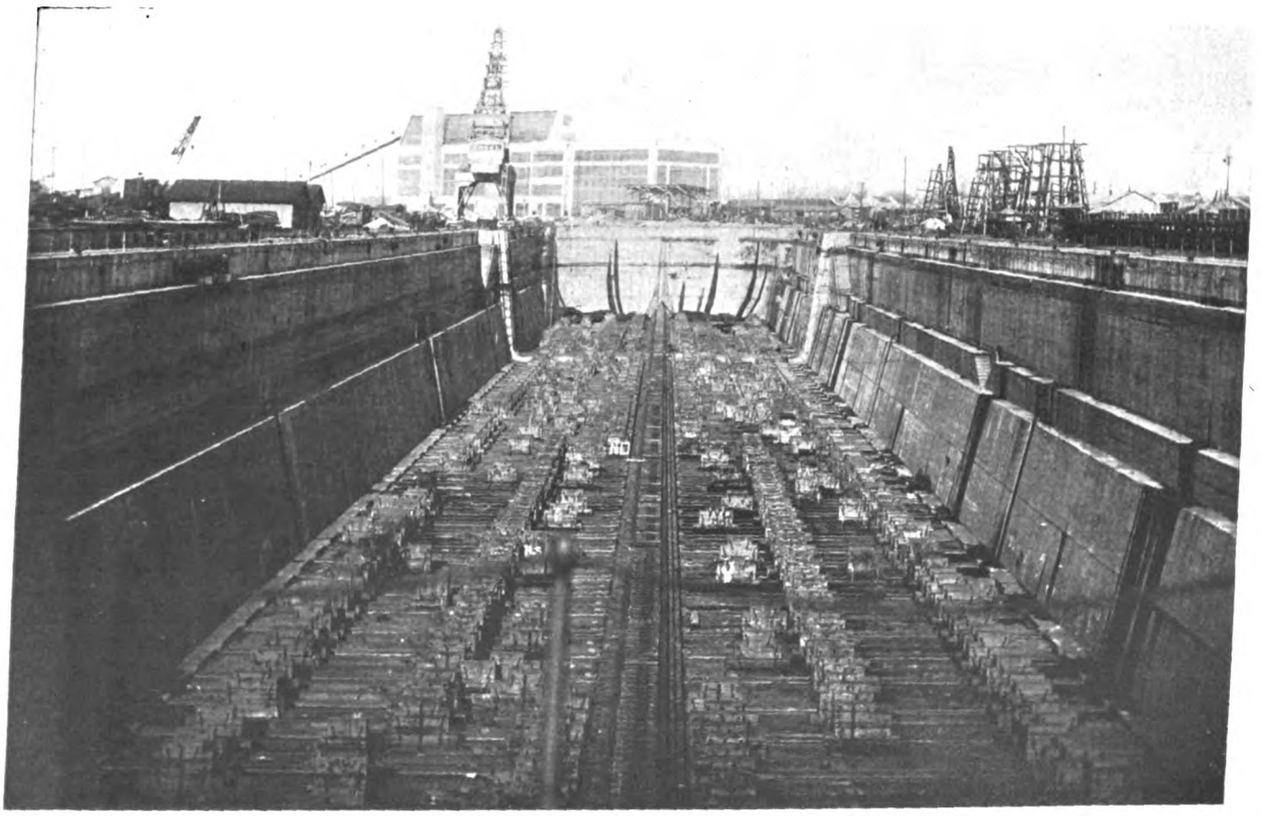

Fig. 3.—Dry Dock No. 4, Taken from Caisson During Last Week of February, 1920

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in connection with the excavation, the pile driving and the water-soaked bank at the river end of the structures. A mode of procedure similar to that used in constructing dry dock No. 4 was adopted and the execution of the work carried out accord ngly. The same machinery used in building dry dock No. 4 was employed, including the drag lines, the concrete plant, locomotives, etc., each for its special duty. The "forms" were of a very ordinary nature and almost childlike for the men to handle after their experience with those of dry dock No. 4.

As a steel cofferdam had been built completely around the water end of the two structures, no great difficulty was encountered in executing the work, although extreme care had to be exercised as the work approached the river-front, due to water conditions. Considerable ingenuity was also required in handling the excavation and driving the piles at the water end of the dry docks, because of the fact that, while it was impossible to operate the drag line in the usual manner, it was necessary to use it co-ordinately with a derrick in getting the steam hammer over some of the wooden piling at this part of the structures.

The initial flooding of docks 6 and 7 took place in the presence of the King and Queen of Belgium, who, with their full escort, attended the dedication exercises, the Queen acting as sponsor.

As the caissons for these two docks had been built at the head of dock No. 7, it was possible to put them in place and pump out dock No. 7 before the dredge removed the dike across the water end. Dock No. 6, therefore, remained full of water until there was a sufficient draft around the entrance to move its caisson from dock No. 7.

Construction of the Docks a Record Achievement

The construction of dry docks 4, 6 and 7 at the Norfolk Navy Yard under war conditions established an epoch in American engineering and contracting. Dock No. 4 was completed and ready for the docking of its first vessel—the battleship *Wisconsin*—26½ months after the beginning of excavation. Docks 6 and 7 were ready for their first ships 18 months after the beginning of their excavation. All three docks were completed and ready for use 37½ months from the starting of excavation on dock No. 4 in January, 1917. As the excavation work on docks 6 and 7 began seven months before the completion of dock No. 4, the unique situation of the simultaneous construction of three concrete dry docks by the same construction company and the same field organization existed, an event never before undertaken in this country (possibly not in any country). The above record will no doubt stand for many years before it is ever equalled or even approached, the record hitherto having been 4½ years for an 850-foot granite-lined dock built at the Puget Sound Navy Yard.

As government engineers and contractors in general are well informed from past experiences, graving dock construction ranks high among the list of uncertain and risky classes of construction work, the construction and fiscal failures in this class of work in the past in this country being notorious—so notorious that but few contractors have sought a second time to undertake such work. While many reasons exist in explanation of this fact, the principal ones are lack of exact knowledge of the underlying soil conditions and the risk involved therefrom, *inexperience in graving dock construction, improper methods of construction* and lack of capital and proper engineering skill. Other well-known items accompanying government contracts have each and all been contributory causes combined with unforeseen acts of nature and troubles too innumerable to record in certain cases. Thus the successful construction in record time under war conditions of three graving docks by the same construction company takes high rank among the engineering and construction achievements of the world war.

While granite-lined and wooden graving docks of increasing size to meet the increase in displacement of our war vessels have frequently been built by the Government in our Navy Yards, concrete graving docks are more or less of a new type of structure, especially where the "arch theorem" is used. In fact, as far as it can be ascertained, with but few exceptions, no such type of dry dock exists in this country outside of Government Navy Yards or stations, the only arch types being the three new docks at the Norfolk Navy Yard and the dock under construction at the Philadelphia Yard. Hence, very little data exist concerning the designing and construction of such types of structures except in government offices and among those who have been associated with their design and construction in responsible positions. Thus the record made at the Norfolk Navy Yard in the construction of dry docks 4, 6 and 7 stands out conspicuously in the annals of marine engineering work.

Standardization of Plain Limit Gages

A sectional committee of the American Engineering Standards Committee has just been organized to undertake the standardization of plain cylindrical gages for general engineering work, under the sponsorship of the American Society of Mechanical Engineers. The immediate occasion for undertaking the work was a request of the British Engineering Standards Association for co-operation on the subject. The committee held its organization meeting on June 11. It is understood that this committee will recommend to the American Engineering Standards Committee that the scope of the work should be broadened so as to cover all plain limit gages for general engineering work.

The present personnel of the committee is as follows: E. C. Peck, chairman, general superintendent, Cleveland Twist Drill Company; L. D. Burlingame, vice-chairman, industrial superintendent, Brown & Sharpe Manufacturing Company; H. W. Bearce, secretary, gage department, Bureau of Standards, secretary, National Screw Thread Commission; P. W. Abbott, Lincoln Motor Company; John Bath, president, John Bath & Company, Inc.; Earle Buckingham, engineer of standards, Pratt & Whitney Company; Fred H. Colvin, associate editor, *American Machinist;* W. A. Gabriel, chief draftsman and designer, Elgin National Watch Company; F. O. Hoagland, vice-president and works manager, The Bilton Machine Tool Company; Edward H. Ingram, works manager, The Cleveland Drilling Machine Company; J. O. Johnson, office of chief of ordnance, War Department; A. W. Schoof, gage engineer, Greenfield Tap & Die Corporation; G. T. Trundle, consulting engineer, Engineers Building, Cleveland, Ohio; H. L. VanKeuren, The VanKeuren Company.

Pipe Flanges and Fittings Standardized

The American Society of Mechanical Engineers has been requested by the American Engineering Standards Committee to assume sponsorship in the standardization of pipe flanges and fittings. In 1914 the society issued a report covering a schedule of pipe flanges and fittings for diameters from 1 to 100 inches for 125 pounds pressure, and also a schedule for extra heavy pipe, covering a range from 1 to 48 inches diameter and for 250 pounds pressure. In 1918 a supplementary report was published for working pressures of 50, 800, 1,200 and 3,000 pounds.

While the work has not been active during the last year, it is now proposed that it be continued, the society being formally recognized as sponsor, under the rules of the American Engineering Standards Committee.

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Method of Estimating Steel Hull Weights

How Curves from Weight of Ships Already Built May Be Expanded and Curves Plotted for Various Divisions of Hull Steel

BY G. F. S. MANN, B. SC.

ESTIMATING has been described as an art, but it may be reduced to a science. The well-known method of plotting curves from the weight of ships already built may be conveniently expanded, and curves plotted for various different divisions of the hull steel. The advantage of this subdivision is, that the weights in each case are plotted against some factor which bears a different relation to the particular weight in question, so a very much greater accuracy is obtained in the curves than is obtained when the total hull steel is plotted against some one factor which endeavors to take into consideration all parts of the hull at once.

Classification of Vessels

Before the groups of weights are taken up in detail the method of classifying the subdivisions will be explained. All tankers are put in one class, which is then divided into multi-deck ships of full scantling, and shelter deck ships. Separate curves on different sheets are drawn for each of these groups. Freight steamers are in one class, divided into three groups, namely, full scantling ships of two or more decks, shelter deck ships and single deck ships. A further class contains combined freight and passenger ships, which are similarly divided into full scantling ships and shelter deck ships. Curves are plotted for each one of these kinds of ships and each ship has its weight divided into eight groups, as will be shown. The seventh group (miscellaneous items) has eight divisions in it.

Thus for each ship fifteen curves are drawn to show the weights of the different parts, and as we now have seven groups of ships (not taking into account the difference between transverse and longitudinal framing, which only affects certain groups of weights), there are in all one hundred and five different curves to be plotted to show the weight of these three classes of merchant ships.

The accompanying diagram, Fig. 1, shows the method of subdividing the weights in the case of a tanker, but the same method is applicable to any vessel.

The following subdivision of the hull has been tried in actual practice and has given useful results:

1. Keel and framing.
2. Shell plating.
3. Inner bottom plating.
4. Decks.
5. Bulkheads.
6. Foundations.
7. Miscellaneous.
8. Erections.

The first five of these groups, containing as they do all the strength members of the ship up to and including the continuous deck, will be considered in detail first. The weight of the keel and framing should be plotted against the factor $L\ (2B + D)$, for when dividing the weight by this factor it will be found that the coefficient obtained is nearly equal to the weight per square foot of the material in question. This follows, as $L \times 2B$ is approximately the area of the floors plus the keel, while $L \times D$ is found nearly to equal the developed area of the frames on both sides of the ship, from the inner bottom to the continuous deck.

The curves plotted for various types of ships show remarkable similarity, and also indicate that the coefficient of weight per square foot increases a little more rapidly than the size of the vessel.

In plotting the keel and frame item separate curves for transversely framed ships and longitudinally framed ships should be drawn on the same chart, where the actual advantage of one system in respect to weight over the other for any given size of ship is obtained directly by subtracting the ordinates of one curve from the other.

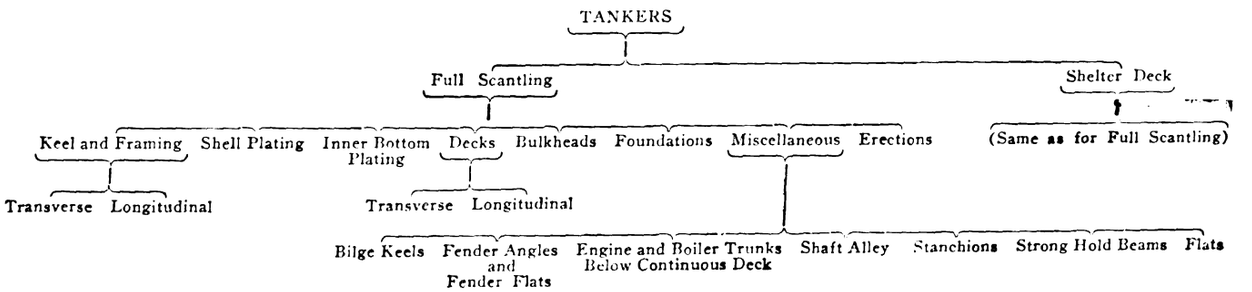
If the weight of the shell plating is plotted against the factor $L(B + 2D)$, it will again be found that the coefficient obtained by dividing the weight by the factor will be approximately the weight per square foot of the plating.

Similarly the inner bottom plating weight is plotted against the factor $l_{1b} \times B$, where l_{1b} is the length in feet of the inner bottom in question, and B the molded beam of the vessel. The breadth of the inner bottom is here assumed to be proportional to the beam, and while this is an arbitrary assumption it yet gives a means for comparison in different vessels, which is all that is here required.

Under the heading "decks" only the continuous deck (and the orlop, if any) are considered. Decks of erections should be taken in group number eight with the other erection weights. The weights of the decks should be plotted against the factor $B \times l_{dk}$, where l_{dk} is the sum of the lengths of the decks. As in the case of inner bottoms the term B in the factor is an arbitrary assumption, and used merely to give a definite basis for comparison. Curves for both systems of framing should be plotted in this group also, for the purpose of comparison as before.

In all ships, except oil tankers and molasses tankers,

FIG. 1.—DIAGRAM SHOWING METHOD OF SUBDIVIDING WEIGHTS OF TANKER



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etc., the bulkhead weights are plotted against the factor $B \times D \times$ (number of transverse bulkheads). This is found to give a good basis for comparing weights. In the case of tankers where the longitudinal bulkheads have to be taken into consideration, the weights are plotted against $B \times D$ (equivalent number of bulkheads). The equivalent number of bulkheads is equal to the sum of the transverse bulkheads plus the figure obtained by dividing the length of the longitudinal bulkhead by B. That is to say the longtitudinal bulkhead is simply considered to be equivalent to so many transverse bulkheads.

It is difficult to find a logical basis for comparing the weights of foundations. Twin and triple screw ships are, of course, separated from each other, and also from single-screw steamers, and Lloyd's longitudinal numeral $L(B+D)$ is adopted as the factor against which to plot the weights, but the curves so obtained are very irregular, and are practically valueless.

Under the heading "miscellaneous" are a great number of items, and at first an attempt was made to plot the sum of these items against the factor $L(B+D)$ on the assumption that similar ships should have similar weights of miscellaneous parts. However, this assumption proved to be quite wrong, and so the miscellaneous group is now divided into the main subdivisions shown below.

(a) Bilge keels.
(b) Fender angles and fender flats.
(c) Engine and boiler trunks below continuous decks.
(d) Miscellaneous trunks and ducts.
(e) Shaft alleys.
(f) Stanchions.
(g) Strong hold beams.
(h) Flats.

When subdivisions (a) and (b) are separately plotted against L, fairly uniform results are obtained.

Subdivision (c) is plotted against $B \times D$, which also gives useful results.

Similarly subdivision (d) is plotted against $B \times D$.

Subdivision (e) is plotted against L_{sa}, when L_{sa} is the length (or in the case of more than one screw the sum of the lengths) of the shaft alley, and the results obtained show this to be a fair assumption.

The rest of the miscellaneous items are each plotted against $L(B+D)$, but, with the exception of the case of stanchions, the results obtained are poor.

In the eighth main group it was at first attempted to plot the erection weight against $B(l_p + l_b + l_t + \ldots)$, where l_p represented the length of the poop, l_b the length of the bridge, etc. The curves were not as uniform as thy should have been, and it was necessary to modify the factor and use the summation of $B_p l_p + B_b l_b + \ldots$ etc. B_p, being breadth of poop, B_b breadth of bridge, etc. When this is done fair curves are obtained.

In all cases the weights are plotted as ordinates, and the proportional factors as the abscissae. The curves are all found to bend toward the ordinate, showing that the scantlings increase more rapidly than the size of the ship.

When the somewhat arduous work has been done, and the elemental weights of the different members of various types of vessels classified in the manner described above, the designer has at his disposal a very complete and handy set of data for quickly estimating the weight of any new vessel.

Of the older methods in vogue, the best known was called the "Cubic Number" method. This consisted in taking a coefficient for the entire vessel, as follows:

$$\frac{L \times B \times D}{100 \times \text{weight of steel}} = \text{cubic number.}$$

This cubic number was fairly independent of the size of the vessel ranging from .40 to .44 for transverse vessels, and from .38 to .42 for longitudinally framed vessels. Here, however, the scientific accuracy of the new method herein described is missing and the omission of decks, bulkheads, etc., had to be allowed for by the experience of the designer.

In the case of firms having considerable data in the form of weights of vessels actually built, the method which was formerly employed was that known as the "off and on."

When a new design was under consideration the scantlings were reduced to a "straight Lloyd's" scantling. A type vessel was similarly reduced and the weight of the two vessels compared. Such data as the weight of 10-foot length amidships, and of 1 inch difference in depth or beam, were previously calculated for the pattern vessel.

Experience has shown, however, that the "elemental method" described in this paper is the most accurate and the most foolproof of all former methods.

Testing the Hull Structure of Ships—III

Rules and Methods for Testing Chain Lockers, Shaft Tunnels, Decks and Deck Erections, Cargo Oil Compartments and Cofferdams

BY F. K. RUPRECHT

TEST NO. 14.—CHAIN LOCKERS

Note.—Often the chain locker is built into the fore peak tank and is hence tested at the time of the test on this tank. Should, however, the fore peak not be arranged to carry ballast, or if the chain locker projects into the No. 1 cargo hold or, in fact, any other compartment, it is required to test it to insure that in the future no damage to cargo or stores or vessel itself will result from the leakage of this compartment. The chain locker is provided with drain pipes draining into the bilges or direct to the pump lines. If the chain locker is provided with drain holes so as to drain directly into some compartment, as the fore peak, for example, it need not be tested.

(*a*) *Object*

To test tightness of the chain locker and drain pipe connections thereto.

(*b*) *Classification Societies' Rules*

1. American Bureau of Shipping and British Corporation Registry.

No specific requirement.

2. British Lloyd's Register.

No specific requirement.

3. Bureau Veritas.

No specific requirement.

(*c*) *Procedure of Testing*

Test before painting with bitumastic or other composi-

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tion, and after all work within and adjacent to chain locker has been completed and the workmanship has been inspected and passed by the surveyor. If it is necessary to test before the surveyor has inspected the workmanship, due to launching date or other contingencies, the final approval of the test cannot be given until such workmanship has been passed. Any finding of the inspector which makes necessary work which may affect the tightness of the structure will make a re-test obligatory.

Fill the locker with water to a depth of about two feet over the bottom, after plugging the drain pipe or shutting the valve in the drain line. The bottom of the tanks and the sides, where under water, and the drain pipe connections should show no leak under this head. Any leaks or defects developed should be made good by legitimate means and all to the satisfaction of the surveyor.

TEST NO. 15.—SHAFT TUNNEL

(*a*) *Object*

To test watertightness of shaft tunnel, thrust recess and tunnel recess flat.

(*b*) *Classification Societies' Rules*

1. American Bureau of Shipping and British Corporation Registry.

To be tested with a hose after all work affecting the tightness has been completed, the pressure of the water in the hose being not less than 30 pounds per square inch. The test is to be carried out under simultaneous inspection on both sides of the plating.

2. British Lloyd's Register.

To be tested upon completion with a hose, the pressure of water in the hose being not less than 30 pounds per square inch, under simultaneous inspection on both sides of the plating.

3. Bureau Veritas.

To be tested with a hose. (Note.—No minimum pressure is specified.)

(*c*) *Procedure of Testing*

Test before cementing, cement washing or painting with bitumastic and before fitting ceiling and after all work within and adjacent to the tunnel has been completed and the workmanship has been inspected and passed by the surveyor. If it is necessary to test before the surveyor has inspected the workmanship, due to some contingencies, the final approval of the test cannot be given until such workmanship has been passed. Any finding of the inspector which makes necessary work which may affect the tightness of the structure will make a re-test obligatory.

Direct a stream from a hose under the required pressure of not less than 30 pounds per square inch upon the outside of the tunnel in a systematic manner, taking each side and top separately and working fore and aft or vice versa, so as to test all seams and butts, boundary angles, column foundations and all other riveted connections. The speed of progress with the hose and the method of advancement is to be so regulated as to permit the surveyor on the inside to inspect all parts thoroughly. No leaks should show up under this test, but if any are found they are to be made good by legitimate means all to the satisfaction of the surveyor.

TEST NO. 16.—FREEBOARD DECK

Note.—The freeboard or bulkhead deck must be calked and made tight whether covered by a watertight superstructure deck or whether exposed throughout or exposed partially. If the decks are of wood or wood sheathed, they are nevertheless to be tested in a like manner.

(*a*) *Object*

To test the watertightness of the freeboard deck casing and house coamings and all connections to the deck, to insure the seaworthiness of the vessel and to insure that in heavy weather no water will enter the hold to damage cargo, machinery, fuel oil or the vessel itself.

(*b*) *Classification Societies' Rules*

1. American Bureau of Shipping and British Corporation Registry.

To be tested with a hose after all fittings are fastened in position. The water pressure in the hose is not to be less than 30 pounds per square inch.

2. British Lloyd's Register.

To be tested with a hose. (Note.—No minimum pressure is specified.)

3. Bureau Veritas.

No specific requirement.

(*c*) *Procedure of Testing*

Test before painting with bitumastic or coating with cement or other deck composition and before any internal sheathing in quarters or other compartments is fitted, and in the case of wood decks or steel decks wood sheathed, after all seams have been calked and payed and after all work on deck has been completed and the workmanship has been inspected and passed by the surveyor. If it is necessary to test before the surveyor has inspected the workmanship, due to some contingency, the final approval of the test cannot be given until such workmanship has been passed. Any finding of the inspector which makes necessary work which may affect the tightness of the deck will make a re-test obligatory.

Clear the deck of all loose dunnage and direct a stream from a hose under the required pressure upon the deck in a systematic manner so as to test all seams, butts and riveted connections as well as the foundation clips, mast connections, hatch coamings, manholes, pipe connections and all other fittings. The speed of progress and method of advancement is to be such as to allow the surveyor on the under side to keep pace with the impinging stream. The deck should be absolutely tight under this test, and any leaks which may develop should be made good by legitimate means, all to the satisfaction of the surveyor. In some cases it may be desirable or convenient to test the deck by plugging up the scupper and blanking off the freeing ports and flooding the decks to a depth of 12 to 18 inches. This gives a very good test under the proper conditions.

TEST NO. 17.—FORECASTLE, POOP, BRIDGE DECKS; COMPLETE OR PARTIAL SUPERSTRUCTURE DECKS; AWNING AND SHELTER DECKS

Note.—All decks exposed to the weather are to be calked, whether of steel or wood or wood sheathed.

(*a*) *Object*

To test the watertightness of all decks, companionways, hatch coamings, skylights and trunks exposed to weather, and all casings to house coamings to insure the comfort of the crew and passengers and the safety of the cargo from damage due to water.

(*b*) *Classification Societies' Rules*

1. American Bureau of Shipping and British Corporation Registry.

To be tested with a hose after all fittings are fastened in position; the water pressure in the hose is not to be less than 30 pounds per square inch.

2. British Lloyd's Register.

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To be tested with a hose. (Note.—No minimum pressure is specified.)

3. Bureau Veritas.

No specific requirement.

(*c*) *Procedure of Testing*

Test before painting with bitumastic or coating with cement or other deck composition and before any internal sheathing in quarters or other compartments is fitted, and after all work on deck has been completed and the workmanship has been inspected and passed by the surveyor. If it is necessary to test before the surveyor has inspected the workmanship, due to launching date or other contingencies, the final approval of the test cannot be given until such workmanship has been passed. Any finding of the inspector which makes necessary work which may affect the tightness of the structure will make a re-test obligatory.

Clear the deck of all loose dunnage and direct a stream from a hose, under the required pressure, upon the deck in a systematic manner so as to test all seams, butts and riveted connections as well as foundation clips, mast connections, hatch coamings, manholes, pipe connections and all other fittings. The speed of progress and method of advancement is to be such as to allow the surveyor on the under side to keep pace with the impinging stream. The deck should show absolute tightness under this test, and any leaks which may develop should be made good by legitimate means, all to the satisfaction of the surveyor.

TEST NO. 18.—FORECASTLE, BRIDGE AND POOP FRONTS; SIDES AND FRONTS OF ALL EXPOSED DECK HOUSES, OR ERECTIONS, INCLUDING ENGINE AND BOILER CASING

Note.—Forecastle, bridge and poop fronts to be of a substantial construction and be made watertight; all exposed deck houses are also to be of ample strength and be watertight, as are to be the engine and boiler casings, where exposed to weather, or where protected by a non-watertight structure. Houses and casings which are a good distance above the load waterline and are not subject to blows of seas, etc., need not be tested. This latter question is one for the judgment of the surveyor.

(*a*) *Object*

To test the water and weather tightness of all erections exposed to weather to insure the comfort and safety of the crew and passengers, and in the case of the engine and boiler casings, the safety of the machinery, and in the case of the bridge and poop fronts, the safety from damage of the cargo, and in all cases, the safety of the vessel itself.

(*b*) *Classification Societies' Rules*

1. American Bureau of Shipping and British Corporation Registry.

No specific requirements.

2. British Lloyd's Register.

No specific requirements.

3. Bureau Veritas.

No specific requirements.

(*c*) *Procedure of Testing*

Test before coating with bitumastic or other solutions and before fitting any internal sheathing and after all work within and adjacent to the structure has been completed and the workmanship has been inspected and passed by the surveyor. If it is necessary to test before the surveyor has inspected the workmanship, due to launching date or other contingencies, the final approval of the test cannot be given until such workmanship has been passed. Any finding of the inspector which makes necessary work which may affect the tightness of the structure will make a re-test obligatory.

Direct the stream of water from the hose under a pressure of about thirty pounds per square inch against the structure to be tested in a systematic manner so as to test the seams and butts, angle and all other riveted connections, watertight doors, cargo ports, port holes, pipe connections and all other fittings. The speed of progress with the hose and the method of advancement are to be so regulated as to permit the surveyor on the other side to inspect all parts thoroughly. No leaks should develop under this test, but if any are found, they are to be made good by legitimate means, all to the satisfaction of the surveyor.

TESTING OF BULK OIL CORNERS

Note.—The testing of oil corners will not differ from the tests given in the preceding section except in the case of the cargo oil tanks and cofferdams. The tests for the latter two are given separately.

TEST NO. 19.—CARGO OIL COMPARTMENTS

(*a*) *Object*

To test the oiltightness and strength of the transverse boundary bulkheads, the centerline bulkhead, the shell in way of the tank, the deck forming the crown of the tank, the longitudinal bulkheads forming the sides of the expansion trunk, the deck forming the top of the expansion trunk, all manholes, hatches and hatch covers and all pipe connections to decks, bulkheads or shell.

(*b*) *Classification Societies' Rules*

1. American Bureau of Shipping and British Corporation Registry.

To be tested before launching or when in dry dock with a head of water at least one foot above the highest point to which oil has access in pipes, hatchways or elsewhere; or to a head of not less than six feet above the highest point of the expansion trunk, whichever is the highest.

2. British Lloyd's Register.

To be tested before launching or when in dry dock with a head of water eight feet above the highest point of the expansion trunk.

3. Bureau Veritas.

To be tested before launching or when in dry dock with a head of water eleven feet above the crown of the tank or four feet above the expansion trunkway hatch covers, whichever is the highest.

(*c*) *Procedure of Testing*

Test before launching and before painting, except that a light coat of red lead on the shell is permissible, but bulkheads and decks should be uncoated, and after all work within and adjacent to the tank has been completed and the workmanship has been inspected and passed by the surveyor. If it is necessary to test before the surveyor has inspected the workmanship, due to some contingency, the final approval of the test cannot be given until such workmanship has been passed. Any finding of the inspector which makes necessary work which may affect the tightness of the structure will make a re-test obligatory.

Fit a standpipe onto the crown of the tank or hatches (vent pipe may be used) and carry the pipe to the prescribed height, fitting a large funnel or other container at the top, the height of which is to be such as to show the level of the water when at the testing head. No leaks or defects should develop at this pressure, and any found

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should, of course, be made good by legitimate means to the satisfaction of the surveyor. Often it is not possible to test completely before launching, and in this contingency it is necessary to have a preliminary test to insure the tightness of the shell in way of the tank. In this case the tank is filled with water to a level well up into the expansion trunk in a two or more deck vessel, and nearly to the deck level in a single deck vessel with an exterior expansion trunk, and the shell made tight under this head to the satisfaction of the surveyor.

Since these tanks will carry oil, and in view of the fact that oil is more searching than water, the surveyor's inspection of workmanship and test will be most rigid and a superior job will be insisted upon throughout.

TEST NO. 20.—COFFERDAMS

(*a*) *Object*

To test the oiltightness and strength of the transverse boundary bulkheads, the centerline bulkhead, the shell in way of the cofferdam, the deck forming the crown of cofferdam, the longitudinal bulkheads forming the sides of the expansion trunk, the deck forming the top of the expansion trunk, all manholes, hatches and hatch covers and all pipe connections to decks, bulkheads or shell.

(*b*) *Classification Societies' Rules*

1. American Bureau of Shipping and British Corporation Registry.

To be tested before launching or when in dry dock with a head of water at least one foot above the highest point to which oil has access in the pipes, hatchways or elsewhere; or to a head of not less than six feet above the highest point of the expansion trunk, whichever is the highest.

2. British Lloyd's Register.

To be tested before launching or when in dry dock with a head of water to the top of the hatchway.

3. Bureau Veritas.

(No specific requirement differentiating between cargo oil tank and cofferdam.)

To be tested before launching or when in dry dock with a head of water eleven feet above the crown of the tank or four feet above the expansion trunkway hatch covers, whichever is the highest.

(*c*) *Procedure of Testing*

Test before launching and before painting, except that a light coat of red lead on the shell is permissible, but bulkheads and decks should be uncoated, and after all work within and adjacent to the cofferdam has been completed and the workmanship has been inspected and passed by the surveyor. If it is necessary to test before the surveyor has inspected the workmanship, due to some contingency, the final approval of the test cannot be given until such workmanship has been passed. Any finding of the inspector's which makes necessary work which may affect the tightness of the structure will make a re-test obligatory.

Fit a standpipe onto the crown of the tank or hatches (vent pipe may be used) and carry the pipe to the prescribed height, fitting a large funnel or other container at the top, the height of which is to be such as to show the level of the water when at the testing head. No leaks or defects should develop at this pressure, and any found should, of course, be made good by legitimate means to the satisfaction of the surveyor. Often it is not possible to test completely before launching, and in this contingency it is necessary to have a preliminary test to insure the tightness of the shell in way of the tank. In this case the tank is filled with water to a level well up above the waterline (about the same level as used for testing the shell in way of cargo oil tanks) and the shell made tight under this head to the satisfaction of the surveyor.

Since these cofferdams are part of an oil-carrying vessel, the surveyor's inspection and test will be most rigid and a superior job will be insisted upon throughout.

When testing to Lloyd's requirements it is to be noted that no standpipe will be required and the cofferdams in this case need only be tested with a head of water to the top of the hatch coamings.

Note.—It is usual to subject the pump rooms to the same test as the cofferdams.

In speaking of repairing leaks, the term "legitimate means" has been frequently used. To the experienced shipbuilder this term will have a very definite meaning, but to the less experienced, judging from jobs I have personally seen, this term will have no meaning at all. Some of the present-day so-called shipbuilders, i. e., car and barge and bridge builders, consider any means as legitimate. Below will be found some of the things which are not legitimate. It should be noted that this is not a complete list, since new and devious means are invented or resurrected from the graveyard every day.

1. Calking the heads of panhead or button head rivets, or calking the points of button or snap pointed rivets.
2. Ring calking rivets, i. e., instead of calking a rivet into the countersink to try to calk it into the solid plate by scoring a deep ring into the plate around the rivet.
3. Calking pieces of packing and waste into a joint.
4. Calking in dutchmen where the heel of the bar is off, due to poor beveling.
5. Calking loose or defective rivets.
6. Welding where re-calking has failed to make the job tight.
7. Painting with bitumastic and other heavy paint.
8. Cementing.
9. Applying "Smooth On" or other patent composition.
10. Re-calking a bar where it is seen that the leg stands off the plating.
11. Re-calking a seam which shows by the depth of calking that it was not originally drawn up tight before riveting.
12. Red lead gunning without the permission of the surveyor.
13. Calking sheet lead or wire lead or sheet steel into a seam, butt, corner or under the heel or toe of a bar.

This, when all summed up, means that testing time is not the time to patch up a bad job. A poorly done piece of work usually requires drastic action before entire satisfaction can be obtained, and it is better to tear it out and replace than to spend a long time trying to patch it up. Of course, minor leaks can usually be fixed up rather easily, but serious ones, or minor ones from a serious cause, always require the renewal of some part and re-riveting. It should be noted that a well done piece of work never gives serious trouble on test except in cases of poor design, and I have found that time and time again a poor job is only made worse by monkeying with it, so that it is always cheaper in the end to face the issue and make the job right rather than following the path of least resistance and doing as little as possible. This latter is a policy for which the highest officials of the company are often directly responsible. It is admitted that a poor job can often be made temporarily tight and pass the test, but ships should be built to go to sea—not to dry dock.

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It is hoped that the foregoing list of tests will show how important a subject the testing really is. Time and money can be saved in shipyards by planning the work so as to arrange for tests in a logical order, and an attempt should be made to give the "testing gang" the proper opportunities to prepare the various tanks for test in a predetermined order and at dates so fixed that it will be unnecessary to postpone the launching day, trial day or any of the other "critical dates."

There is annexed a table of static pressure due to various heads of salt and fresh water. This table has been figured to only one place in decimals, since for ordinary testing work this is sufficiently accurate.

TABLE OF WATER PRESSURES

Head in Feet	Pressure in Pounds per Square Inch — Fresh Water	Salt Water
1	.4	.4
2	.9	.9
3	1.3	1.3
4	1.7	1.7
5	2.2	2.2
6	2.6	2.6
7	3.0	3.1
8	3.5	3.6
9	3.9	4.0
10	4.3	4.4
11	4.8	4.9
12	5.2	5.3
13	5.6	5.7
14	6.1	6.3
15	6.5	6.7
16	6.9	7.1
17	7.4	7.6
18	7.8	8.0
19	8.2	8.4
20	8.7	8.9
21	9.1	9.3
22	9.5	9.7
23	10.0	10.3
24	10.4	10.7
25	10.8	11.1
26	11.3	11.6
27	11.7	12.0
28	12.1	12.4
29	12.6	12.9
30	13.0	13.3
31	13.4	13.7
32	13.9	14.2
33	14.3	14.5
34	14.7	15.0
35	15.2	15.6
36	15.6	16.0
37	16.0	16.4
38	16.5	16.9
39	16.9	17.4
40	17.3	17.8
41	17.8	18.3
42	18.2	18.7
43	18.6	19.1
44	19.1	19.7
45	19.5	20.1
46	19.9	20.5
47	20.4	21.1
48	20.8	21.5
49	21.2	21.9
50	21.7	22.4

The United States Battleship Tennessee

(*Concluded from page 643.*)

The British vessels carry less fuel when in the normal or trial condition than do the vessels of either the United States or Japan.

The *Tennessee*, it will be noted, is 900 tons greater in displacement than the *Pennsylvania*, the first of our 30,000-ton battleships. Although larger in displacement, the advance in propelling machinery has made it possible for the *Tennessee* to attain the same steaming radius as the *Pennsylvania* upon less oil fuel. This, together with the 900 tons increase in displacement, has made practicable the fitting of more complete torpedo protection, individual turret gun mountings in lieu of the single slide type, 50-caliber, 14-inch guns instead of the 45-caliber type, and the modern type of bridge and superstructure.

Sheet Metal, Salt Air, and Rust

BY BENNETT CHAPPLE*

SALT air and the variations of temperature along the seaboard, because of the severe corrosive conditions, leave the marine engineer continually face to face with the great problem of rust. He knows that salt air and moisture stimulate an electrolytic action among the impurities of steel and that on this account the deterioration of ordinary sheet metal is rapid. Instead of a normal, uniform oxidation, the metal flakes and crusts under the action of the elements like the loose bark of a tree.

The first real effort to combat the rust problem with high quality sheet metal was the manufacture of a pure iron in commercial quantities by the American Rolling Mill Company, Middletown, Ohio, which produced what is known as the Armco brand of American ingot iron. Before this time the cost of pure iron was prohibitive for general use. When placed upon the market it attracted attention, because the theory that iron would resist rust in proportion to its degree of purity seemed to be borne out by the chemical and metallurgical tests of old iron that had resisted the ravages of time.

Millions of dollars are spent each year in sheet metal replacements along the seaboard, so that the engineers who have designed and constructed docks and warehouses on both the Atlantic and Pacific coasts have made a special study of the cause and prevention of corrosion. The engineers who built the Savannah docks at Savannah, Ga., the municipal pier at San Francisco, and the great Curtis Bay coaling station at Baltimore, were among the first to adopt pure iron because of its rust-resisting properties. The construction of the Cristobal and Balboa coaling stations in the Panama Canal zone under government engineers was another instance of the selection of pure iron instead of steel for sea coast construction in order to eliminate the danger of rust. The Dravo Construction Company, Nevills Island, Pittsburgh, Pa., was one of the first to adopt galvanized American ingot iron in the construction of dredges and hoist and mixer boats. Several of these boats were placed in service in 1913, and after six years of hard service it is said that the iron plates and fixtures show no signs of deterioration. It is also interesting to note that in the Ford *Eagle* patrol boats, which were under construction during the war, American ingot iron was used exclusively in smokestacks, boiler casings, stokers, sheathing, cowls, lockers and shaft casings.

In heavier plates American ingot iron is used for deck plates and safety treads. It has proved suitable for all sorts of sheet metal or plate work on board vessels where a tensile strength of less than 44,000 pounds is required and where corrosion is to be combated.

The United States Steamboat Inspection Service has given very careful consideration to the subject and has recently approved pure American ingot iron as qualified to meet the government specifications for charcoal iron in lap welded boiler tubes. In marine welding, pure iron has been found to be well adapted as a filler, both in speeding up the operation and in maintaining the uniformity of welds. In this connection the Newport News Shipbuilding and Dry Dock Company, Newport News, Va., after investigating various grades of welding materials, adopted pure iron as giving the most satisfaction.

* American Rolling Mill Company, Middletown, Ohio.

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The Repair Equation in the Future of the American Merchant Marine

BY WALDON FAWCETT

That facilities for ship repairs, no less than resources for ship construction, are requisite to the upbuilding of an adequate and creditable United States merchant marine, is a fact that has all along been apparent to experienced and practical men in the maritime industries, but which has only been brought home to the general public in consequence of the hearings and investigations incident to the formulation and enactment of the new merchant marine law. It has been made clear, indeed, that the capabilities of American agencies for ship repair may dictate the development and distribution of the nation's shipping, even more surely than will the capacity of American shipyards gage the volume of additions to the merchant fleet.

THE American conscience, which has lately been so remarkably quickened with reference to the merchant marine, has but to hark back to the experiences of the steel navy of the republic to find convincing evidence that ship repair facilities should keep pace with, if not outstep, vessel construction. Time and again in the history of the United States Navy has there been consternation in official circles, when it was discovered that a new naval building programme called for battleships of dimensions not to be accommodated in any existing dry dock. Even more recently, as illustrative of the influence of the repair factor, there was observed the feeling of unrest and uncertainty that was created in American shipbuilding circles when reports were circulated to the effect that the United States Navy Department would attempt to carry on all repair work on the Government fleet at navy yards.

Congress Investigates Ship Repairs

The most interesting information that has been adduced with respect to the post-war conditions in the United States in the field of ship repair and reconditioning operations has lately been brought out as a result of first-hand investigations in various cities by a select committee of the House of Representatives delegated to make an investigation of the activities of the United States Shipping Board. In its quest for information this Congressional commission has consulted at length with various officials, and notably with Mr. Robert Lyons Hague, formerly of the United States Shipping Board Emergency Fleet Corporation. Mr. Hague, a naval architect, who is now with the Standard Oil Company of New Jersey, has recently held the position of Director of the Construction and Repair Department, in charge of all repair and reconditioning work, including the letting of contracts.

In an outline at Washington of the practice of his office, Mr. Hague made it clear that in the reconditioning of the ships (cargo, cargo and passenger, or passenger vessels) turned back by the War Department as the military need relaxed, it was the policy of the Shipping Board to let contracts as the result of competitive bidding and in most instances to make contracts direct rather than through agents. An exception was made, however, in the case of the *Leviathan*, formerly the *Vaterland* of the Hamburg-American Line, in the case of which a contract* was entered into with the International Mercantile Marine to act as agent in connection with the reconditioning work. Explaining why an intermediary was desirable in connection with this record-breaking repair job, the Fleet Corporation's executive in charge of repairs said:

Reconditioning the Leviathan

"The *Leviathan*, which is the largest vessel in the world, presented to America the most difficult problem that has ever been put before the American merchant marine in the way of reconditioning. Nobody in this country, outside of the International Mercantile Marine, had the experience in big ships that was so necessary in a job of this magnitude. For the Government to have gotten together the skilled force necessary, providing they could have gotten them together—because practically all the leading talent is engaged or connected in some way or other with different enterprises—would have been an enormous expense and we considered it a great waste of time." Incidentally, Mr. Hague revealed that as a prelude to preparations for reconditioning an effort was made to obtain from Germany the original plans of the *Leviathan*. "We cabled the builders to quote us a price on a complete set of blue prints for that ship," he related. "As I remember, they quoted us $1,000,000."

To shipbuilders and shipowners who have occasion to conduct negotiations involving repair work, the details of the contract between the Emergency Fleet Corporation and the International Mercantile Marine Company may be of interest. Under this compact the International Mercantile Marine was to receive as compensation for agency representation the sum of $15,000 per month from the time of the commencement of the services until the steamer went to her berth for loading. And subject to the sale of the vessel the owner further agreed to assign the *Leviathan* to the agent for operation and management for a period of five years from the time that the vessel goes on berth for loading, terms to be agreed upon.

Contract with the International Mercantile Marine

The primary service to be performed under this contract by the agent in charge of repairs consists in supervision of the preparation of plans and specifications for the reconstruction, repairing and outfitting of the *Leviathan*, these plans and specifications to belong, of course, to the owner. In order to execute the commission entrusted under the contract the agent agreed to contribute on its account, so far as may be necessary, the services and office expenses of its executive officers, including chief and assistant chief of construction, chief inspector, chief draftsman, superintendent engineer, marine superintendent, passenger and freight experts, victualing superintendent and clerical assistants. Officers and crew and personnel for the maintenance of the steamer were to be employed by the agent for the owner's account and there was also reserved the right to employ, with the approval of the owner's representative, technical experts, the latter subject to discharge

* Now that the Shipping Board is trying to sell the *Leviathan*, it is a question whether this contract will be carried out.

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on the written request of the owner or his representative. The agent is by the contract empowered to enter into contracts for materials, machinery, equipment, supplies, etc., but all purchases in the amount of $5,000 or over and all contracts are subject to the approval of the owner.

An exchange of views with respect to repair work, that is not without significance with respect to ship repair work in general, was conducted incident to the formulation of a programme for the *Leviathan*. This took the form of a round-table conference attended by representatives of leading American shipbuilding and repair firms. The first question that came up at that conference was whether in the case of a repair job of indefinite nature it is possible to obtain from repair interests a lump sum price. On this point J. W. Powell, vice-president of the Bethlehem Shipbuilding Corporation, said: "I think, if I would do the job, I would split it in two parts. I would do as much as was reasonable to do on a fixed price basis—coal burning change to fuel oil, electric lighting, plumbing, etc.—and the rest on a cost-plus fee basis." Mr. Powell further suggested that, if desired, the work could be divided into certain big items, as, for example, the fuel oil installation, and that each of these items could be handled on a fixed price basis, leaving the other items to go on the cost-plus plan.

Cost-Plus vs. Lump Sum Basis

An opposite view regarding the possibilities of the administration of repair work was taken by W. F. Gibbs, chief of construction of the International Mercantile Marine Company. His idea was that with the exception of oil fuel installation, great difficulty was bound to be encountered in subdividing repair work. Granted that such operations as plumbing, ventilation, electric installation, interior communication and joiner work must proceed as a whole, it would be bound to beget complications to have a number of firms operating simultaneously. Mr. T. Ross, repair manager of the Newport News Shipbuilding and Dry Dock Company, was one of the participants in the conference who opposed the adoption of the cost-plus plan for repair work of the character of that on the *Leviathan*. He declared that adoption of that formula "would be demoralizing to the shipbuilding business." Explaining the limitations that exist in ship repair work, he commented: "The difficulty most repair people have in doing jobs on a fixed sum is not in giving a definite price on the work as specified, but it is difficult to estimate on your general clauses. The difficulty comes when working out. General clauses in reconditioning jobs give the difficulty in so far as definite quotations on missing parts are concerned. Sometimes these are taken care of in a separate item. If done on that basis, I do not see why a contractor should not be able to get it on a lump sum basis."

An incident of the reconditioning operations on the *Leviathan* that has attracted some attention in shipping and shipbuilding circles involved the construction and installation of "sample staterooms." Given a feeling of uncertainty as to just what was desirable in the form of interior appointments on the ship, it was concluded that rather than risk the expense of revisions and alterations of joiner work it would be preferable to construct several sample staterooms which would permit the executives to form opinions from actual inspection rather than to depend on plans alone for guidance. Accordingly, several "sample" staterooms were constructed at commercial rates, the thought being to provide the repair firm that should ultimately be given the contract with a model or standard room.

That bids for repair or reconditioning work must, of necessity, vary between limits, depending on whether the bidder submits his bid for the items specifically stated or whether the intent of the specifications as clearly implied be bid upon, is the theory of Lieutenant-Commander F. S. Crisp, general work superintendent, hull division, New York Navy Yard. Explaining this principle for the benefit of the special Congressional committee, the naval specialist said: "In the case where it is necessary to refit a ship, it is almost impossible in my opinion to detail specifically every single item of work that is to be done, and the specifications usually written covering this class of work state that the work is to be done, say, in accordance with the best commercial practice or in accordance with the approval of the person awarding the contract. The painting of a bulkhead would be a simple example—where it cannot be definitely decided whether the bulkhead must be scraped to the bare wood or whether the painting may be done without scraping. In the case of refinishing woodwork, it is quite impossible to state whether all woodwork is to be removed, and it is usually stated that all woodwork that is necessary shall be renewed. The person bidding on the clause in the contract would necessarily have to use his own judgment as to just how far the work should be renewed.

"Again, in the case of overhauling plumbing or piping it is not usually possible to specify in detail just what sections of pipe or what particular valves are to be overhauled, and it is therefore customary to write the specifications to cover only the general overhauling of such and such a system, such as a sanitary system. The person bidding will necessarily examine a number of sections of pipe or a number of drain lines, and will base his bid on the general condition of the ones which he actually examines."

Preparation of Plans and Specifications

"The problem of the preparation of plans and specifications for extensive repair or reconstruction work has been the subject of considerable discussion in the course of the Congressional investigation of Shipping Board operations in the repair field. On one occasion the chairman of the special committee asked Mr. Hague, director of construction and repairs, whether in the case of the reconditioning of the *Leviathan* the Shipping Board would not have saved money if it had procured the original plans, even though it was necessary to pay the German builders the demanded sum of $1,000,000 for a complete set of blue prints.

"We would not have affected any saving whatsoever," was the declaration of the head of the repair department. "With the original plans in hand we would still have had to have taken—unless we scrapped everything in the ship and put in a complete installation—the pains of finding out the actual condition of the various parts that are integral in a passenger ship, such as ventilation, plumbing, heating, wiring, etc. We would have had to go to the trouble of making a survey of each of these individual items to satisfy ourselves as to their condition, or we could have taken the original plans, scrapped everything, and duplicated them. To my mind the means taken was far more efficient and far less expensive, for, with an expenditure of approximately $300,000, we obtained plans and specifications ready to secure a bid. Now, even though we had paid a million dollars for the detailed plans from Germany, we would still have had to go to the expense of making a survey as we have done."

Capacity of American Ship Repair Plants

Incident to the Congressional inventory of the Shipping Board's practices and policies with respect to repair work, there has been considerable discussion of the capabilities

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and capacities of American plants for ship repair work. In this discussion, Shipping Board officials have actively and steadily defended the principle that, even at the risk of seeming discrimination, it is the part of wisdom for the shipowner or operator to entrust his repair work only to plants whose ability to execute all that they may undertake is unquestioned. On this score, Director Hague, on one occasion, said: "It is rather a serious question whether you want to give, on a government contract, an opportunity to bid to a firm you do not think has the proper organization—and that is not meant in any way detrimental to their organization—because if you do give them a chance to bid and they are the low bidders, then they are entitled to it. The time to draw the restriction is before you give out the specifications. In my experience in awarding a lot of jobs, both on main contracts and on subcontracts, in the construction at Philadelphia, it frequently has happened that a firm that has not the qualifications both as regards the personnel and as regards equipment has been given an opportunity to bid on some government work and has proven itself the lowest bidder. Then you have got to give them the contract and it has created all sorts of trouble to try to make them live up to it. We consider that a job of importance should be negotiated with only responsible people, and I mean by that responsible in every way—not simply financially responsible or morally responsible, but taking into consideration their organization, personnel and equipment."

QUALIFICATIONS OF SHIP REPAIR COMPANIES

When President Philip A. S. Franklin, of the International Mercantile Marine Company, was in Washington, he was asked whether, incident to activities of his company in the role of agent for the United States Shipping Board, any standard of qualifications was fixed which must be met if shipbuilding yards or repair plants were to have an opportunity to figure on repair and reconditioning work of magnitude. His reply was: "No detailed standard was agreed upon. We had our knowledge of exactly what the situation was at the various plants, or an idea of the capacity and the ability of the various yards of the country. We considered their financial responsibility and the matter of technical staff was very much in our minds."

It turned out that one firm with a yard in the vicinity of New York felt aggrieved that it was not given an opportunity to bid on the *Leviathan*. President Franklin, when asked about this, replied: "My impression is that they are not sufficiently staffed and equipped to do a job of this kind. They are very good people. I am not casting the slightest reflection upon them. If we had ordinary repairs to be made, we would be very glad to consider them." W. F. Gibbs, chief of construction of the International Mercantile Marine, was asked also why one yard that aspired to undertake the biggest of repair jobs was not given an opportunity to figure on the contract, and he replied: "I did not feel that their experience was such as to justify their taking work of this magnitude."

An angle of the repair proposition as it is now presented in the United States which may have more or less significance for private interests is found in an inclination on the part of the Government to utilize the enlarged facilities of United States navy yards for repair work on merchant vessels, and, coincident with this trend, a disposition on the part of the executives and agents of the Shipping Board to give preference to the navy yards in contracting for repair work. Director of Construction and Repairs Hague is on record with regard to the reconditioning of the *Leviathan*: "Personally, I would rather see the job done at a navy yard than at a commercial yard. We get better workmanship." President Franklin, of the International Mercantile Marine, has also declared for execution at navy yards of repair work on government ships, particularly if there enters in the question of keeping occupied a navy yard force.

Standardization of Structural Shapes

Recommendations of Sectional Committee on Steel Shapes for Adoption of Anglo-American Standard Beam Sections

ON the entrance of the United States into the war with the Central Powers there came a demand for immediate increase in ship construction which, in turn, meant increased production by the steel mills. To increase production to the maximum and to simplify order practice, a conference of steel makers was held in Washington on July 2, 1917, at which was adopted American standard practice for structural steel for ships.

The result of this action proved distinctly beneficial both to the mills and the shipyards, but was not followed immediately by a standardization of and a reduction in the number of structural shapes used at the yards, and in consequence the Emergency Fleet Corporation undertook an investigation to ascertain definitely the number of structural shapes used in shipbuilding and the possibility of their standardization and reduction in number. As an outcome of these investigations carried on by Fred T. Llewellyn in the Division of Steel Ship Construction under Daniel H. Cox, manager, it became possible to determine what were the sections in most general use and at the same time were brought out clearly the divergences in the sections rolled by different mills.

ADOPTION OF BRITISH STANDARD SECTIONS

At a conference of steel makers held in Philadelphia on November 19, 1918, inasmuch as the British standard sections of ship channels and shipbuilding bulb angles appeared to be better adapted to economical manufacture than the American standard sections, and inasmuch, further, as the new rolls which had been turned in recent years to produce such sections conformed in general to British standards, it was decided that thereafter American standard sections should be discontinued and that rolls not then to British standards be redressed at as early a date as possible to roll such sections as closely as possible to British standards, and this particularly in view of the further fact that the adoption of British standard sections would enable American mills to compete on an even basis for ship steel wherever utilized in shipyards, either at home or overseas.

REVISION OF BRITISH STANDARD SECTIONS

The British standard sections thus adopted as American standards were those adopted by the British Engineering Standards Association as published in 1903, and it was

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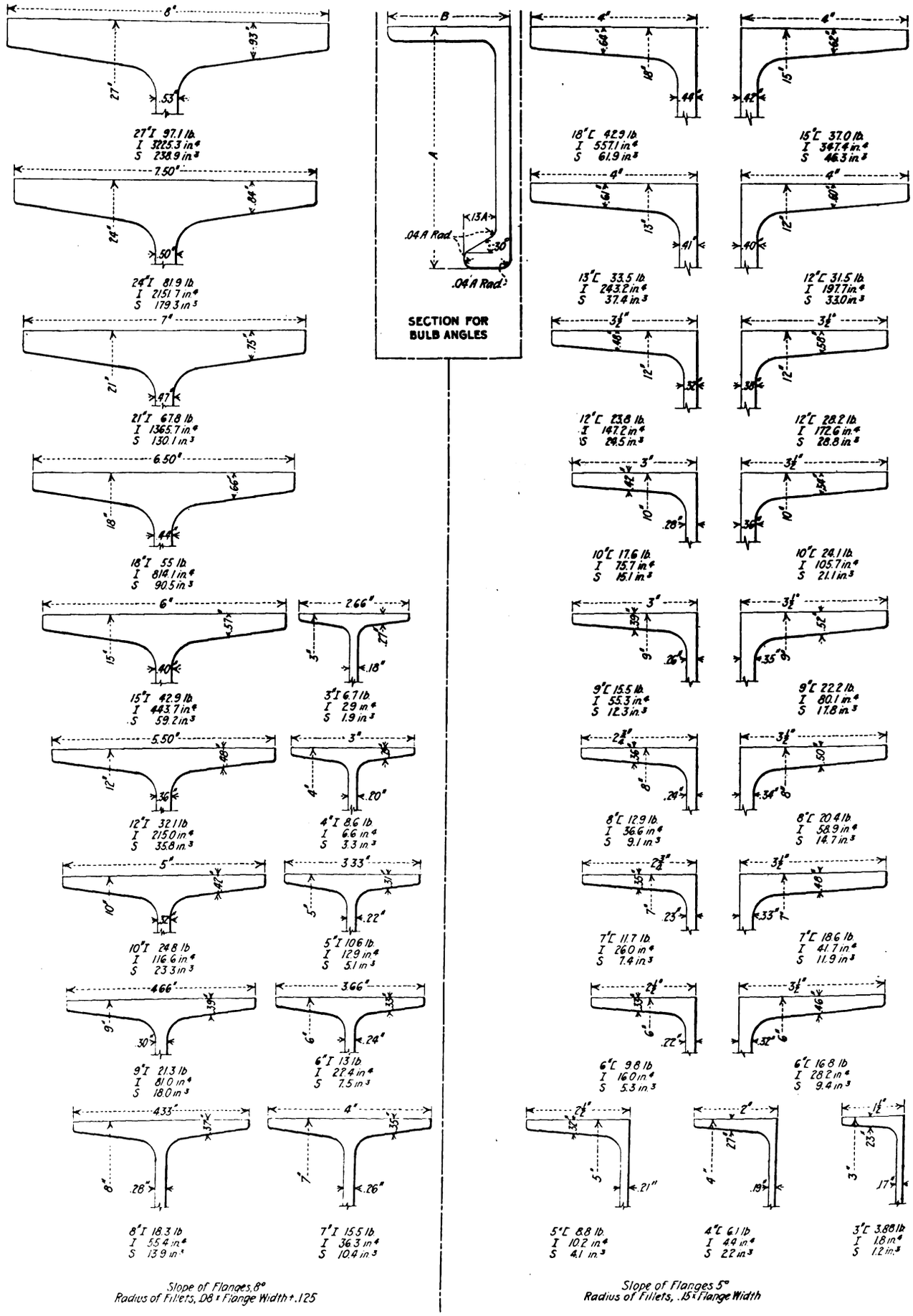

Fig. 1.—Bulb Angle, Channel and I-Beam Sections Recommended for Adoption as Standards

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not known that this association had undertaken a revision of the British standard sections in 1913, work on which, however, had been suspended by reason of the war activities. When, however, through the trade press information as to what had been done in the United States came to the attention of the British Engineering Standards Association, that association advised American steel makers as to the situation, and later through their secretary, Mr. LeMaistre, expressed their desire to have the American structural trade co-operate with the British Engineering Standards Association in the formulation of common Anglo-American standards for structural shapes.

ORGANIZATION OF SECTIONAL COMMITTEE

At the instance of the Association of American Steel Manufacturers, a sectional committee on steel shapes was organized under the auspices of the American Engineering Standards Committee. This sectional committee is composed as follows:

American Bureau of Shipping
Captain C. A. McAllister
David Arnott
John Martin

American Society of Civil Engineers
J. H. Edwards
J. B. French
H. G. Balcolm

Association of American Steel Manufacturers
R. B. Woodworth (chairman)
G. H. Blakeley
Geo. E. Thackray

Railway Car Manufacturers' Association
A. E. Ostrander

Society of Naval Architects and Marine Engineers
Fred T. Llewellyn
E. H. Rigg
J. W. Stewart

United States Navy
Commander C. M. Simmers
Lieut. Com. H. D. Rouzer

RECOMMENDATIONS OF SECTIONAL COMMITTEE

The sectional committee gave a very careful consideration to the entire routine of structural practice in the United States not only as it affects the profiles of structural shapes themselves, but also as regards methods of order, practice, calculation and publication of weights, areas and properties, etc., with the idea to insure as far as possible a complete accord between makers and users wherever the sections rolled in English-speaking lands were used. At its meeting held on April 27, 1920, it formulated its recommendations for submission to its sponsor organizations, to the American Engineering Standards Committee and to the British Engineering Standards Association as a basis for common Anglo-American standards, and its conclusions are now to go before these organizations for further discussion and endorsement. The essential features of these recommendations are:

(1) The adoption of the decimal system for the expression of dimensions, thicknesses and other elements of order practice.

(2) The adoption as an Anglo-American standard of the standard order practice adopted by the Association of American Steel Manufacturers on February 20, 1920, under which structural shapes are to be ordered by weights per foot and not by thickness.

(3) The adoption as an Anglo-American standard of American standard practice as it relates to ranges of thicknesses, methods of computation and methods of publication.

(4) The adoption of definite ranges in thicknesses of angles and other structural shapes, under which are established two zones of variations between minimum and maximum thicknesses. Under .60 inch thick variations are fixed at four one-hundredths (0.04) inch, and above .60 inch thick at eight one-hundredths (0.08) inch.

(5) Included in the list of angles is an equal angle (9 by 9) and four unequal angles (8 by 4, 9 by 4, 9 by 6 and 10 by 4), which are not now rolled in the United States but are subject to the considerations which weigh with manufacturers when new rolls are contemplated.

(6) The adoption of a new line of bulb angle sections as proposed by the British Engineering Standards Association that are recommended on account of their greater efficiency as compared with present British and American standards.

(7) The adoption of a single line of channel sections with a 5-degree flange taper to displace the present two American lines, the structural line with its flange taper 9 degrees 27 minutes 42 seconds and the shipbuilding line with its flange taper of 2 degrees. This line of channel sections is not quite in accord with that proposed by the British Engineering Standards Association, but is believed to be more suitable to the requirements of the American trade and better proportioned.

(8) The adoption of a new line of beam sections to take the place of the present American standards adopted in 1896. These sections have wider flanges than present American standards and do not agree very closely with the British proposals, but are believed by the Sectional Committee to be more nearly in accord with the recent developments in the fabrication of buildings and bridges.

Fig. 1 shows the new lines of bulb angle, channel and I-beam sections recommended for adoption as standard.

Motorship Cubore

THE motorship *Cubore*, of 11,500 tons deadweight, built and engined by the Bethlehem Shipbuilding Corporation, Ltd., is propelled by a two-cycle Diesel oil engine of 3,200 horsepower, designed by Arthur West, consulting engineer of the builders. After successful trials the vessel has just gone into service, carrying ore from the Bethlehem Steel Corporation's Cuban properties to the Bethlehem plants in the United States.

This ship represents an important advance in marine engineering in the United States, as its heavy oil Diesel engine, designed by an American and built by Americans for use in an American ship, represents this country's first successful attempt in a field that thitherto has been held exclusively by foreign interests. The *Cubore* has a length over all of 469 feet, a length between perpendiculars of 450 feet, a molded beam of 57 feet and a depth molded to the upper deck of 37 feet. The deadweight carrying capacity is about 11,500 tons. At normal speed the main engine turns over at 105 revolutions per minute.

In addition to the Diesel propelling machinery, an oil-fired Scotch boiler with 1,800 square feet of heating surface has been installed, designed to carry a working steam pressure of 140 pounds per square inch for auxiliary purposes.

LAUNCH OF S. S. BOSWELL.—Messrs. Harland & Wolff, Ltd., recently launched from their yard at Belfast the steamship *Boswell*, a standard cargo ship of the "B" type, building to the order of Messrs. Lamport & Holt, Limited, Liverpool. The length of the vessel is 413 feet 4 inches, the beam 52 feet and the gross tonnage 5,200. Propulsion is by double reduction geared turbines capable of developing 2,300 shaft horsepower.

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Forced Lubrication for Marine Engines

Application of Forced Lubrication to Reciprocating Engines—Arrangement for Oiling Main Bearings, Crank Pins and Crossheads

BY LIEUTENANT-COMMANDER W. C. OWEN, U. S. NAVY

MUCH time and thought have been given to the question of the development of a satisfactory and reliable forced lubricating system for marine turbine installations aboard vessels of all types. Today we can safely say that we can see the results of the labor that has been expended on this subject, as shown by the more satisfactory operation of these installations and the small repair bills caused by accidents attributed to the failure of the lubricating system. Turbine installations are now fitted with safety devices to take care of the lubrication in case of breakdown of the lubrication system, with warning signals, both visual and sound, to warn the operator in case the system is not operating properly or any bearing is not receiving sufficient oil.

While the above has been going on in the turbine installations, the lubrication on the reciprocating engines of the merchant marine has been practically at a standstill, and we are using the same methods we have used for generations—namely, hand lubrication and sight and wick feed lubrication, except in very few instances when forced lubrication has been installed.

Forced lubrication of engines is not a new idea. It has been successfully used for years in dynamo and blower engines of high rotary speed. About 1906 the British Navy applied this system to its large reciprocating engine vessels, and about 1909 the United States Navy installed it on all battleships then building and authorized it for many of the battleships already built, and for all armored cruisers. These installations have met the expectations of their designers and have proved the wisdom of their judgment, as shown by the improvements noted below:

Increased Reliability—Decreased Friction—Economy of Oil—Reduced Repair Bills

The reliability of the vessel is increased due to the fact that all bearings at all times are supplied with sufficient oil and are not burnt out, delaying the vessel through having to renew or adjust them.

Friction is decreased due to sufficient oil always being supplied to all bearing surfaces.

The oil used is recovered and used over again and again, and there is no loss except through leakage, which can be avoided by careful watching of the system and which can thereby be reduced to an inappreciable amount compared with the hand or sight and wick feed. In this connection I might mention the fact that a forced lubrication system requires a straight mineral lubricating oil instead of a compound lubricating oil as is used in the sight and wick feed. The price of the straight mineral oil is considerably less than that of compound oil and, furthermore, less oil is used, thereby making the savings from oil bills considerably more than would at first appear.

The cost of repairs for renewal of bearings is reduced to a minimum. The writer recently served on a vessel equipped with reciprocating engines fitted with forced lubrication, and during his time of a year and a half on that vessel it was not necessary to renew a single main engine bearing, although the vessel cruised approximately eighty thousand miles during that time. The engine remained in perfect alinement and no work outside of that done by the ship's force was performed on the engines during that time. At the end of that period the engines were in as good condition as at the beginning, if not better.

Fig. 1 shows the usual arrangement for the oiling of the main bearings, eccentrics, crank pin bearings, crosshead pins and guides.

Description of a Typical Installation

As shown in Fig. 1, oil is supplied under a pressure of from 25 to 30 pounds per square inch gage to the main bearings, crank pin bearings, crosshead pins, crosshead

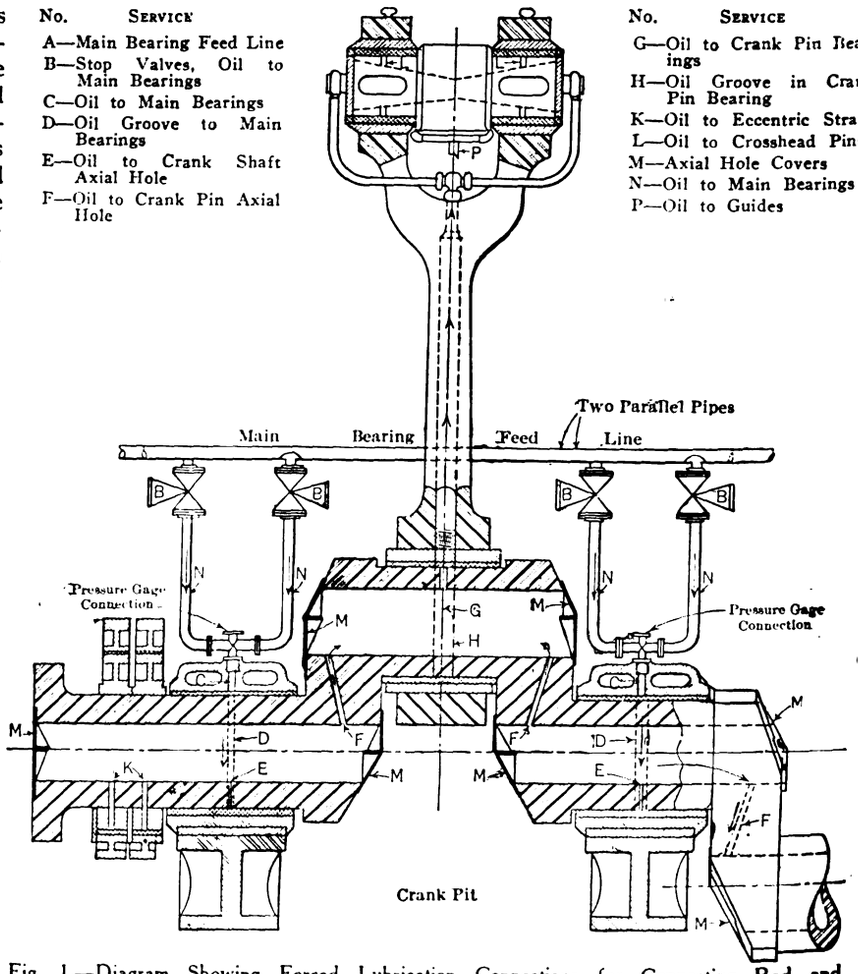
No. Service
A—Main Bearing Feed Line
B—Stop Valves, Oil to Main Bearings
C—Oil to Main Bearings
D—Oil Groove to Main Bearings
E—Oil to Crank Shaft Axial Hole
F—Oil to Crank Pin Axial Hole
No. Service
G—Oil to Crank Pin Bearings
H—Oil Groove in Crank Pin Bearing
K—Oil to Eccentric Straps
L—Oil to Crosshead Pins
M—Axial Hole Covers
N—Oil to Main Bearings
P—Oil to Guides
Two Parallel Pipes
Main Bearing Feed Line
Pressure Gage Connection
Pressure Gage Connection
Crank Pit

Fig. 1.—Diagram Showing Forced Lubrication Connections for Connecting Rod and Crankshaft of Main Engine

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guides and eccentrics. At each main bearing a radial hole is drilled through the crank shaft to the axial hole in the shaft. In the path of the hole in the shaft an annular recess is cut in the main bearing brasses. For oiling the eccentrics a radial hole is drilled in the shaft and an annular recess is cut in the eccentric brasses. The oil is forced out of the side of the eccentrics. The axial hole in the crank shaft is connected to the axial hole in the crank pin by drilling a radial hole in the crank web. Radial holes are drilled in each crank pin to the axial holes in the pin, and in the path of the hole in the crank pin an annular groove is cut in the crank pin bearings. The axial hole in the connecting rod is extended through the crank pin brass to the crank pin. The above forms a closed circuit for the oil from the main bearing supply pipe to the top of the connecting rod. Oil is taken from the connecting rod axial hole by piping to the axial hole in the crosshead pins.

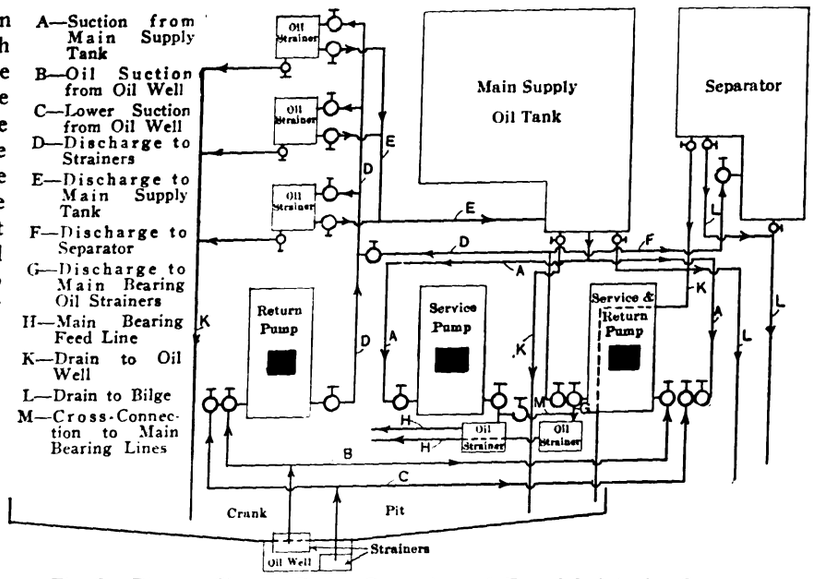

Fig. 2.—Diagram Showing Piping Connections of Forced Lubrication System

Oil-tight cups are fitted at the ends of the axial holes in the crank shaft, crank pins and crosshead pins. A gage and thermometer are fitted on each main bearing.

Referring to Fig. 2, which is a diagrammatic sketch of a typical layout in the engine room, there are located a forced lubrication service pump, a service and return pump and a return pump; a supply oil tank, fitted with cooling coils and oil separator; three strainers, for the supply oil tank; two strainers, for discharge to the engines, and one oil well strainer. Oil is supplied to the bearings by either the service pump or the service and return pump, and passes through strainers, either pump being able to use either strainer or either discharge line. At each main bearing two valves are fitted, one for each oil feed line for the purpose of regulating the flow of oil.

The oil is forced out on the inside of the crosshead pins and falls into a trough carried on the crosshead, whence it is fed to the guides by two pipes. The guides are also lubricated by pipes leading direct from the main supply pipes.

Course of Oil Through the System

The course of the oil through the system is as follows: The service or the service and return pump takes the oil from the supply tank and discharges through a strainer to the engine supply pipes. From the main supply pipes branches take the oil to the main bearings through holes in the bearing caps, to the guides and the manifold, which supplies the link pins, and to the thrust blocks. The annular grooves in the main bearings distribute the oil through the bearings and into the crank shaft axial hole through the radial holes in the journals. The crank pins receive their oil through the radial hole in the crank web connecting the axial hole in the shaft and the axial hole in the crank pin and the radial hole in the crank pin. The eccentrics are lubricated through radial holes drilled in the shaft and eccentrics. The crosshead pins are oiled through pipes leading from the axial holes in the connecting rod to the axial hole in crosshead pins and out through radial holes.

The thrust bearings are supplied by pipes from the main supply lines to which valves are fitted to regulate the flow. After lubricating the bearings, the oil is forced out of the ends of the bearings and drains to the crank pit, which serves as a well for catching the oil. The crank pits are of an oil-tight construction and are fitted with an oil well so constructed that no bilge water or dirt can enter and mix with the oil.

To prevent splashing, the engine is entirely encased with a thin sheet metal casing up to within about twelve inches of the bottom of the cylinders. Doors and sight holes in the casing are provided for observing the operation of the engine.

Branches are led from the main supply pipes to present sight and wick feed manifolds, which feed the link blocks through pipes, as at present.

From the crank pit oil well the oil is returned by the return pump to the supply tank.

The separator provides a means for separating the oil from the water or other foreign matter that may become mixed with it. After being cleaned, the oil is returned to the system through the crank pits.

On those cylinders in which a vacuum is carried it is necessary to fit the piston rod with some form of steam seal to prevent the oil being sucked into the engine and carried over to the boilers in the feed water. Several types of steam seals are now on the market which give satisfactory results.

Alternate Arrangement

An arrangement somewhat better than the above could be made on those vessels having a large engine room hatch, in which the supply tank could be placed at a sufficient height to give the oil a pressure of about 20 pounds per square inch and have the oil fed to the system by gravity.

In this case only two pumps would be required and it would be best to have both connected up as service and return pumps. Normally either pump would pump the oil from the crank pits to the supply tank, whence it would be fed by gravity to the system, or in case of necessity the oil could be taken directly from the crank pits and forced through the system.

Care to Be Taken in Use of System

In using this system, care must be taken to use a pure mineral oil, one that does not saponify and leave a gummy residue. An oil that would saponify, when brought in contact with water (which will be present from small steam leakage along piston and valve rods) and the churn-

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ing movement of the cranks, would cause a lather to form which in time might become too thick to be forced through the pipes and oil-ways. The strainers provided will guard against any dirt or mechanical impurities that might be in the oil, but they do not prevent saponification.

Special oils are provided for forced lubrication and are supplied by all the leading oil companies. No trouble is experienced in obtaining a satisfactory oil. It is not necessary to limit the system to any special brand of oil, as the oils can be mixed with just as good results as obtained by using only one brand of oil, but in no case should a compound or marine engine oil be mixed with a forced lubrication oil. When a vessel is fitted with forced lubrication it is best to have only one kind of oil aboard, that for the forced lubrication system (except special oils such as cylinder oil, ice machine oil, etc.) as this has been used on the auxiliaries with just as good results as from the compound oils.

Motorship Building in Europe

BY OUR SPECIAL LONDON CORRESPONDENT

PROBABLY nothing has excited more interest in Diesel engine circles than the problem of construction of double acting, two cycle engines. The majority of English engineers consider that the double acting type of motor is too complicated to warrant its adoption, but, on the other hand, it is recognized that when it comes to powers of 12,000 horsepower needed for transatlantic liners it is a somewhat difficult matter to meet the necessary conditions in adopting the single acting principle.

Before the war German firms had experimented very extensively with double acting engines, and both at Krupps and at the M. A. N. works three cylinder sets of 6,000 horsepower were built. The engine constructed by the latter concern unfortunately met with a bad accident, which gave a setback to the double acting type. Nevertheless, Blohm and Voss, the well-known shipbuilders of Hamburg, who were connected with the M. A. N. concern, built a motorship in which they installed two double acting Diesel engines. This vessel, named the *Fritz*, was only completed just at the outbreak of war and was therefore never put into commission. Recently she was handed over by the Germans with a large number of other vessels to the British Government and she has lately been put into commission, being run by the Glen Line, which is already well known as owner of a large number of motorships.

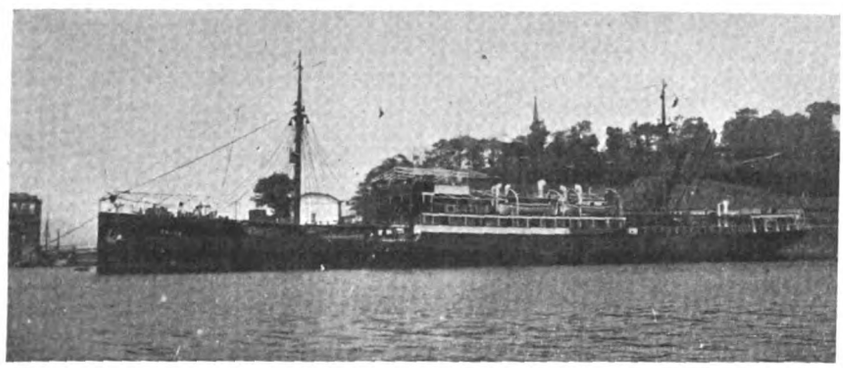

Fig. 1.—Motorship *Fritz*, the Only Vessel Fitted With Double Acting Oil Engines

It is interesting to record, therefore, that in the two or three months during which she has been trading between British and Continental ports, complete success appears to have been obtained with the machinery and the engineers speak very favorably of its operation. The motors are on the small side comprising a couple of 850 brake horsepower sets, but if it is proved that the principle is satisfactory it is not unlikely that some important developments will take place in the construction of larger engines of the same design.

It cannot be said, however, that the engines of the *Fritz* show much advantage over the two or four cycle, single acting motors, since they weigh approximately as much, while the fuel consumption is considerably higher. Moreover, they are extremely complicated, as valves are used for scavenging instead of ports. Naturally, there have to be two fuel valves at the bottom of the cylinder in order to get an equal distribution of fuel, owing to the position of the piston rod, which passes through a specially designed water cooled stuffing box. There are thus three valves to operate in the top cover and four in the bottom cover (two scavenging and two fuel valves), rendering the employment of three camshafts necessary. These camshafts are arranged so that there are two at the bottom and one at the top, all deriving their motion from a common drive from the crankshaft. There are no mechanically operated valves in the cylinder head, since the air is distributed direct to the cylinder covers through air distributors arranged close to the control wheel. Air pipes are taken from these distributors to the cylinder covers in which are only non-return valves.

The engines have cylinder dimensions of 480 millimeters bore and 710 millimeters stroke and develop their full power of 850 brake horsepower at 120 revolutions per minute. There are three cylinders and the scavenging pumps and air compressors are arranged on the engines themselves, which are therefore wholly self-contained. Reversing is accomplished by turning the crankshaft relative to the camshaft through a small angle so as to cause the fuel valves and the scavenging valves to open at the correct position for running in the astern direction. The starting valves are also set to open at the right time according to the direction of rotation by means of a handwheel on the starting platform. The fuel consumption of the *Fritz*, which carries about 5,000 tons of cargo at a speed of 10½ knots, is about 7 tons per day, and the consumption per brake horsepower hour is approximately half a pound, which is some 25 percent above the ordinary four cycle design.

Many extraordinarily interesting developments are now being made in motorship construction, but perhaps none is more important than the building of four large passenger

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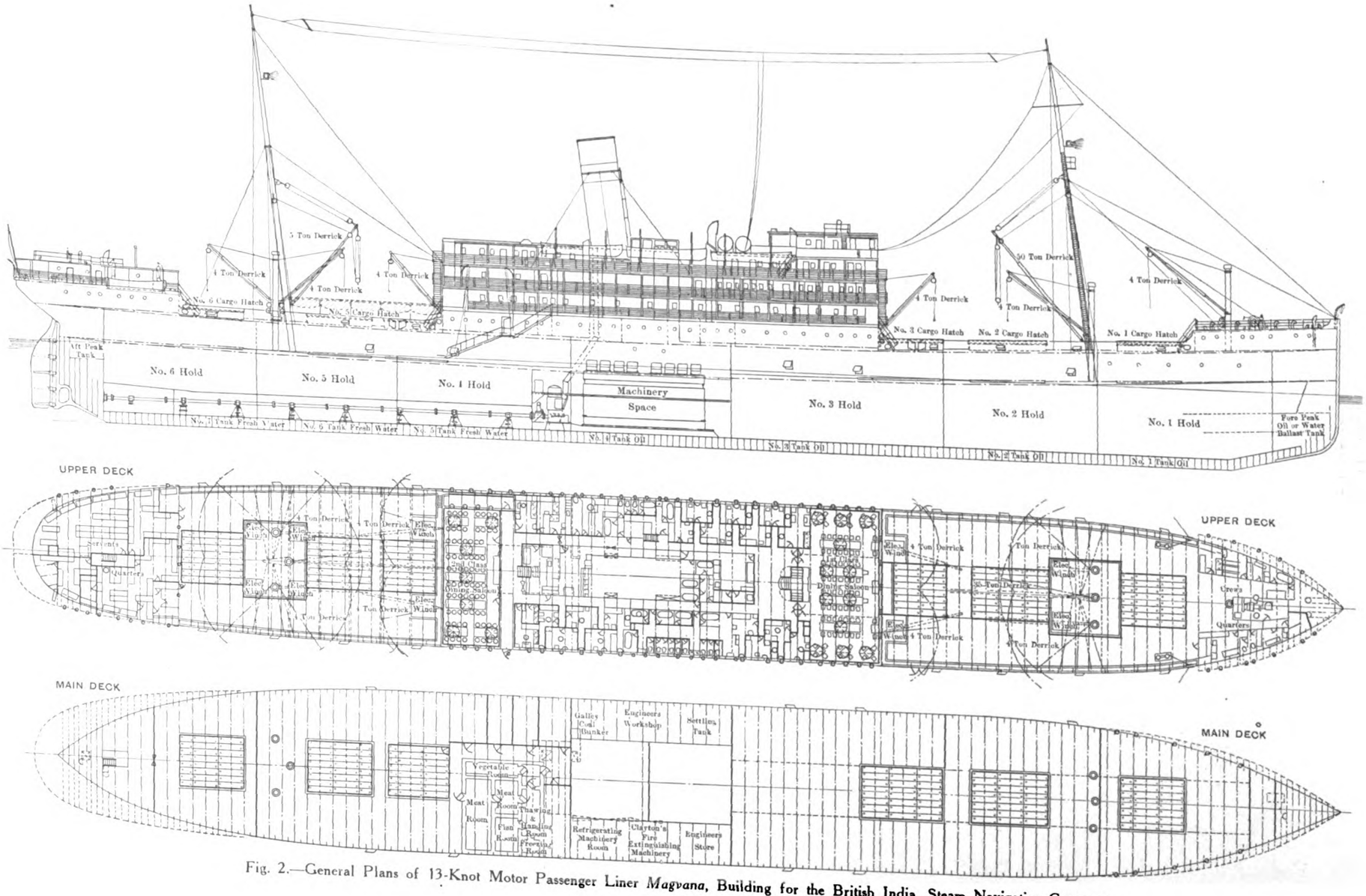

Fig. 2.—General Plans of 13-Knot Motor Passenger Liner *Magvana*, Building for the British India Steam Navigation Company

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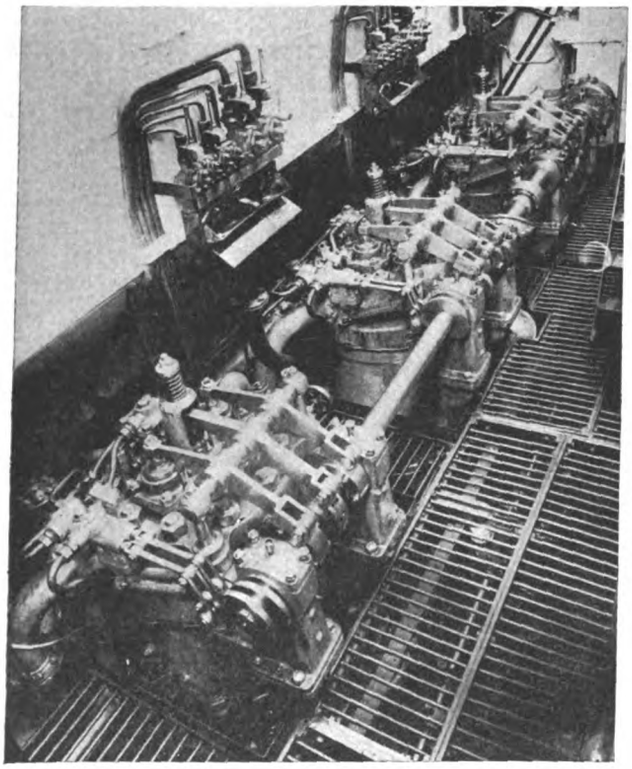

Fig. 3.—Top View of One of the Double Acting Diesel Engines in the Motorship *Fritz*. In Each Top Cylinder Cover Are Two Scavenging and One Fuel Valve

liners for the British India Steam Navigation Company, all of which are now under construction on the Clyde. The first, named the *Magvana,* will be ready for service in the course of two or three months and will be put on the regular British India route between London and India. She is designed to carry about 150 passengers, besides 10,000 tons of cargo, and is a standard class of ship, which hitherto has been built only as a steamer. The engines will also be a departure from ordinary practice, for, while in three of the ships an entirely new design will be used, in the fourth Sulzer two cycle engines are to be fitted.

All the new ships are to be equipped with machinery of between 4,000 and 5,000 horsepower. The engines in the first three ships will be of four cycle type constructed by the North British Diesel Engine Works, two motors being fitted in each vessel. These units will develop 2,300 horsepower each and have eight cylinders 26½ inches diameter and 47 inches stroke, and will be remarkable from the fact that at any rate in the first vessel the air compressors for injection and starting air will not be fitted on the propelling engines, but will be driven separately by Diesel engines.

It is now becoming customary on the majority of European motor vessels to use electrical machinery instead of a steam plant, and this is adopted on the passenger liners, two 400-horsepower oil engines being installed, driving two 40-kilowatt dynamos for the supply of power to the winches and steering gear and for lighting, etc. All the other passenger carrying shipowning companies are greatly interested in this new development, and it is believed that should the new craft be completely successful there will be a very large number of orders placed for similar or larger ships.

Scandinavian shipowners are finding it quite impossible to obtain all the motorships they require from the shipbuilding firms in Norway, Sweden and Denmark, and British shipbuilders are benefiting in consequence. One Clyde yard alone (the Ardrossan Dry Dock and Shipbuilding Company) has five motorships on order, two for Norwegian and three for Danish owners. The first two are 7,000-ton craft, 390 feet in length, fitted with a couple of Werkspoor engines built in England by Hawthorn Leslie and Company, developing a total of 2,500 indicated horsepower. Two of the remaining three are to carry 9,000 tons and will be fitted with Burmeister and Wain machinery, while the fifth vessel is to carry 8,500 tons and will also be equipped with engines built by Burmeister and Wain.

There is absolutely no question that were there more engineering firms in Great Britain in a position to take on orders for the construction of marine oil engines, far more contracts for motorships would be fixed in spite of the fact that there is a distinct slump in shipbuilding and many orders for steamers have been cancelled. The reason is that shipowners are now realizing that for the majority of trading routes the oil-engined vessel will show to the greatest advantage when it comes to the question of cutting freights.

Destroyer Satterlee Breaks Speed Records

ALL American speed records were broken by the destroyer *Satterlee* when she made a mile at the rate of 38.257 knots and averaged 37.272 knots in her five top-speed runs in her standardization trials held off Rockland, Maine, on June 8. The best previous record is 37.04 knots, held by the destroyers *Dent* and *Wickes.*

The *Satterlee* was built by the Newport News Shipbuilding and Dry Dock Company, Newport News, Va., and is one of the latest class of United States 1,200-ton destroyers. Her engines consist of two Westinghouse 14,000-horsepower turbines, each of which drives a propeller through a floating frame gear that reduces the rated turbine speed of 3,050 revolutions per minute to 452 revolutions per minute for the propeller. The power actually developed by the *Satterlee* was, however, 31,223 horsepower, which forms another record for this class of vessel. The maximum speed of her propellers was 486.04.

Each of her turbines consists of two elements—high pressure and low pressure—which drive the propeller through a single 2-pinion gear. Either element can be used independently of the other in an emergency, so that if one element should be out of commission the vessel can still proceed, though at reduced speed. An astern turbine, giving 25 percent ahead power, is incorporated within each turbine element.

The fuel economy of the *Satterlee* is also exceptionally good, being below one pound of fuel oil per shaft-horsepower hour.

JAPAN'S NAVAL PROGRAMME.—The Japanese government has decided to ask for an appropriation of approximately $22,199,499, to be expended in the construction of new warships and other naval requirements for the current fiscal year as part of the national defense. The programme includes the construction of four battleships, four battle cruisers, twelve cruisers, thirty-seven destroyers and a number of other craft. The whole programme is to be completed by the end of 1927, the total expenditure being fixed at over $450,000,000, spread over ten consecutive years.

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Review of Problems Involved in the Production of Motorship Machinery

BY HUBERT C. VERHEY

The attention of the individual and maritime world is now centered upon the question of fuel conservation and general economics more than ever before, owing to either the lack of supply or production of liquid fuel and coal. This situation has once more brought the application of internal combustion motors into the limelight, as no doubt the use of liquid fuel burned under boilers is a comparative waste, a fact which is readily explained when we consider that the actual utilized heat units are approximately three times greater when the fuel is applied direct to the prime mover, as is the case in oil motors.

THE production of heavy oil marine motors, and only such will be described in this article, is practically a new field. It has not been a walkover from the start, which probably counts for much of the undue criticism extended. It has been demonstrated that the introduction of such machinery had to battle with a great number of handicaps, which have been gradually but slowly overcome. When all the facts are generally known and understood it may result in undivided appreciation of the splendid engineering work performed by manufacturers and shipbuilders who cast their lot with this new industry which is conducted along so different lines from steam power practice.

Today cargo carriers equipped with reliable machinery can be seen in overseas service, although in small numbers; hence it may be of interest to follow the general development by mentioning some of the troublesome features encountered. The writer has no intention to make claims that the last word has been spoken notwithstanding the great strides which have lately been made the world over, even during the war.

The Most Modern and Economical Machinery

The subject is very timely, particularly in view of the fact that Congress has authorized the United States Shipping Board to support the development of the most modern and economical machinery equipment for ships to be built in the future by private parties; the only means that will put America in a position to compete on the seven seas and uphold her merchant marine.

Approximately ten years ago internal combustion motors of the Diesel type were first used for the propulsion of sea-going vessels, and they were introduced by European builders. It is interesting to note that the smaller nations were the pioneers in the field as respectively the Hollanders, Scandinavians and Belgians developed marine installations the very moment enough experience was obtained by building stationary motors under German license.

The reason for this may be explained by the fact that all except the Belgians suffered from a lack of coal supply from their own lands and as seafaring nations would benefit by the use of vessels having great cruising radius.

German Development of Stationary Oil Motors

An enormous business developed in the stationary field in Germany was probably the reason that German concerns made comparatively less effort to produce marine motors, as all manufacturers of small as well as large units were prosperous, and apparently rocked themselves to sleep at that time. In fact, the first large crosshead type engines were originated outside of the mother country of the Diesel motor. The grade of perfection to which stationary motors were developed in Germany cannot be denied, but as it goes in engineering, certain principles successfully applied under given conditions are not always suitable to other fields, which has been plainly demonstrated by the failures of certain designs of marine motors.

Early Difficulties

It is reasonable to assume that the preliminary trouble encountered in the manufacture of marine Diesel motors was the fact that the builders did not have a sufficient all-around knowledge of oil motors to combine their previous experience with the essentials for reliability, handling facilities and endurance of such machinery in a ship, but lots of credit is due them for their endeavors to face this costly period of development at their own risk and expense, as it was not a case where the possibility of falling back upon the experience of the originators of the Diesel motor was available. In one instance I know it to be a fact that objection was raised by the license holder to adopt crossheads for marine Diesel motors instead of the trunk type piston then applied. In the early stage of the game licensees virtually kept in close touch with the licensors in order to reduce risks, so that a great deal of credit is due to the progress of builders of the first sea-going motorships.

Similarity to Steam Practice

Analyzing the development, it is of interest to note the efforts of such builders to copy established steam engine practice as much as possible. It really was made a great talking point, and considered a necessity at the time to follow these lines very closely, as it was said to be impossible to operate a motorship successfully unless the personnel could handle machinery which was not very much different from the steam engine practice to which sea-going engineers were accustomed.

This, for instance, is one reason among others for the comparatively slow development and adoption of marine Diesel motors, as it has since been demonstrated that straight reciprocating steam engine practice cannot be followed to the best advantage and the failures that were a result of the early conception have invited undue criticism to the general principles of this highly economical prime mover.

Following the idea that a marine engine should be entirely open—in other words, that all main moving parts should be observed at all times and, if necessary, be touched by the operating engineer—has done its share towards the failures experienced with the early motors. It has been proven that the lubrication by gravity of these parts gave trouble, and it is remarkable to see that manu-

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facturers who from the start adopted the entirely enclosed type, having a forced feed lubricating system, enjoyed better success, which has built up their present reputation.

Owing to the fact that Diesel motors are run with higher bearing pressures than the usual steam engine practice and, consequently, need a greater supply of lubricating oil, the entirely enclosed type of motor offers not only the advantage of a clean engine room, as no lubricating oil is thrown on the floor plates and no oil vapors enter the engine room space, contaminating the atmosphere, but also offers greater safety against overheating.

FORCED LUBRICATION

When a forced feed system is applied, there is, as a rule, a main header running all along the motor, having branches to each main bearing. The oil enters the bearing caps, is conveyed by a groove around the journals, enters a hole in the journal, passes through the hollow journal, is discharged through a passage in the crankweb to a circular groove in the crankpin box and follows its way upwards through a hole in the connecting rod, whence it is distributed to the wristpins and guides. After the oil has done its work on the rubbing surfaces it is squeezed out at the bearing edges and drips down into the crankpit, where it is collected, carried to a sumptank, filtered and used over again.

Sometimes it becomes necessary to cool the oil, particularly when navigating in tropical waters, for which purpose an oil cooler is installed between the discharge end of the lubricating oil pumps and the main supply header.

The pressure carried on the system varies with the viscosity of the oil, but does not have to exceed 15 pounds. In order to be able to meet all conditions such as change in temperature of air and cooling water, the oil pumps should be of ample capacity and should be able to run at variable speed. The same holds good for the types of cooling water pump to be installed.

TEMPERATURE OF THE SEA

In order to be prepared to navigate on all seas, it is necessary to figure with the worst possible condition. For instance, around the Panama Canal the sea may have a temperature of 85 degrees F. (even higher temperatures are on record), and this very fact has caught some builders of marine motors in the early stage of the game. Although their ships might have been designed to run in certain predetermined trade routes, with auxiliaries adequate to meet given conditions, an unexpected change in route would show that insufficient preparations were made.

Conditions of this nature have materially influenced the reputation of motorships and were readily used by opponents, for mere business reasons, to criticize the reliability of motorships in general, the fairness of which I desire to leave to the reader's judgment.

TEMPERATURE OF THE ATMOSPHERE

The changes of temperature of the atmosphere even during different times of the day have a marked effect on the proper functioning of a gravity feed lubricating oil system, as the actual discharge of oil is governed by its viscosity, the number of drops fed being reduced as soon as the cooling effect of the atmosphere makes itself felt. This will clearly show that the whole system depends on the care and interest taken by the operator, who is compelled to make adjustments in many places at different times. The argument is advanced by advocates of a gravity feed system that this is just one of the very good points of the system as a whole, as it tends to keep the operator from losing attention. This may be considered to be a mere statement to defend the particular constructional features of their products, principles of which were decided upon from the start and naturally must be adhered to for production reasons.

On the other hand, assuming that no practical fault can be found with a system which is constantly governed under pressure and which at all times can be controlled by the regulation of either the suction or discharge valve of the lubricating oil pump, while a gage which is properly located at the engineer's hand warns the operator of changes due to either the atmospheric or the cooling water temperatures, then there is no doubt as to the latter's superiority.

PARTITION BETWEEN CRANK CASE AND WORKING CYLINDER

The best designs of existing marine Diesel motors, particularly those of the single acting type, are provided with a partition between the crank cases and the working cylinders. This eliminates the mixing of lubricating oil with the foul gases that escape from the working cylinders past the pistons, when the latter need overhauling. I believe that I am justified in stating that special attention should be paid to features of this nature on board ship, where the working space is limited and the handling facilities are not to be compared with test conditions. In many instances designs have been criticised by the operators for just such reasons, which are not without foundation, although the argument may be advanced that the engines have to be built a trifle higher.

It is true that increased height requires greater rigidity for the foundation and the tanktop, but the object gained more than offsets this disadvantage, as it has given complete satisfaction in service. The lubricating oil consumption of engines of this construction can be held down to a minimum if the crank case doors, drip pans and pipe connections are tight, and it may be readily seen that the return oil is kept reasonably clean so that filtering is materially facilitated.

CRANKSHAFT TROUBLES

Oiling systems, however, have not been the only troubles encountered with the Diesel motors. Crankshafts have broken at most inopportune times—not because the stresses were prohibitive on paper, as they had passed the inspection of the classification societies, which always have been very rigid, but in instances for faulty material or neglect and carelessness of operators, in other cases due to manufacturer's faults or poor design. Among the cases of bad design, it may be mentioned that frequently the designer kept only one point in view, namely, to keep the surface pressure down at all cost. He resorted to two things which we now know to be wrong, but which was not realized at the time. The first was to reduce all fillets to a minimum, the second to make very long journals, which means an increase of the bending moments in the center of the crankpin, as well as an increase in the distance between cylinders, incidentally producing a longer engine.

The approximate cylinder distances of the best of the large marine motors in the market is equal to about twice the cylinder bore. At this distance it has been proved that it is possible to construct a built-up shaft having crankwebs of sufficient width to insure safety, as progress has been made in the method of heat treatment of steel that has materially aided satisfactory production.

Comparing the early designs with those of the present, it is evident that an increase in width of the crankwebs has been made at the expense of the length of journals and to a certain extent of the crankpins, which is a great improvement, and that the forced feed lubricating system is a valuable medium to obtain the safety desired.

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CRANKSHAFT PROPORTIONS

With the design of a crankshaft and its proportions we are guided mainly by the experience gained in actual operation, as it is extremely hard and even impossible to determine by calculation all the factors that affect its strength and endurance, as so many different assumptions can be made. High grade steels are only used in cases of light-weight engines such as submarine engines. Much was thought of nickel steel at one time, but it did not prove to be a success, not even in steam engine practice, as the material eventually crystallized, causing the shaft to break without warning. Crankshafts built of chrome vanadium steel have been successfully used, this material having a tensile strength as high as 105,000 pounds per square inch. The material for slow speed engines is usually an open hearth steel of around 78,000 pounds per square inch tensile strength and of good ductility. Shrink or press fits as applied to built-up shafts vary with the shop practice of the manufacturers, but enough experience is available to insure successful production of crankshafts nowadays.

CAST STEEL CRANKSHAFTS

Of late successful shafts have been built of cast steel. This material shows a wonderful polish after the motors have run for some time. Although the naked eye can detect tiny little black spots, showing that this material is not as close as a forging, it has been unmistakably shown that cast steel is a suitable material and that the very spots seem to be of help in holding the film of lubricating oil. The production of such castings is a matter of foundry skill, the proper application of risers and the annealing of the casting after the rough finish is taken off. As the production of Diesel motors is rather costly as compared with the reciprocating steam engines, the use of castings for the crankshafts will tend to cheapen their manufacture.

Motors with crankshafts having one-piece castings for two webs and a crankpin are now running successfully, and as these designs were accepted by the classification societies, further development may be expected in the near future. The use of cast steel for the crankshafts of large gas engines of 10,000 horsepower, having the crank-arm and the overhung crankpin in one piece, has been a success from the start, and such engines have been successfully running day in and day out for some years in America.

FOUNDATIONS

Foundations have also invited criticism, and weak designs have caused lots of trouble, which has not been beneficial to the reputation of heavy oil motors. In fact, that part of the ship on which the engine foundation rests must be exceptionally strong, particularly with single acting four cycle engines, as the comparatively sudden application of the working load causes forces to act which are not similar to those set up by the double acting reciprocating steam engine. Two cycle engines, even if single acting, work better on the shaft, as the turning moment is more even than that of the four cycle types.

I do not know of any case with large marine engines where bedplates have been particularly weak, but I have reason to believe that the troubles encountered with the pioneer engines of certain manufacturers were carefully watched by other builders, and that, for safety's sake, much unnecessary material was added to their products, which may explain the fact that successful engines are exceptionally heavy. It is only natural to anticipate that successful types are apt to be copied as far as patented features can be dodged, but this gentle act of copying is not of help to rapid development

FOUR VERSUS TWO CYCLE ENGINES

Installations are of the four cycle type and are more numerous than two cycle installations, so that talking points raised in favor of four cycle installations can be more readily demonstrated, putting greater weight in the scale when a decision is pending as to what type of installation is most desirable on board ship. It cannot be denied that the construction of a two cycle motor requires more experience and skill than that of a four cycle motor for the simple reason that the heat problem is increased due to the time element. The actual working stroke occurs every four revolutions in the case of two cycle engines and every alternate revolution with four cycle engines, so that the temperature changes are more severe. This factor, in reality, is the most troublesome in internal combustion motor design and has made itself evident by the failures in early two cycle motors to a greater extent than with the early four cycle motors.

If, however, we study the development of details, it shows clearly that designers were not aware at the time of the weak points of their motors. In many cases very complicated and unsymmetrical castings were used. Symmetry should be made the first consideration and sudden and abrupt changes in metal thickness should be avoided. This knowledge has come to us at the extreme expense of those who underestimated these facts.

OPERATION OF COOLING INSTALLATION

The proper operation of the cooling agent is a point of high importance, velocities should be equalized as far as possible and the supply should be unbroken even after the motors come to a standstill for either maneuvering purposes or after the finish of the run. It really looks absurd to mention it, but it is a matter of record that some early installations were not provided with auxiliary means of cooling water supply for cases as mentioned, which resulted in overheating of the cylinders and pistons and the consequent formation of cracks in these parts. This not only resulted in damage to the motors, but also provided a weapon in the hands of the opponents of heavy oil motors, who pointed, not without reason, to the poor reliability of same.

Local application of high temperatures is a hardship to any casting, and in this respect four cycle motors are worse off than two cycle motors, as their respective inlet and exhaust valves are usually located on the longitudinal centerline of the motors, and it may be readily seen that one side of the cylinder and liner is in a different condition under working conditions than the other, as the cool atmosphere inlet air enters on one side of the cylinder while the exhaust gases are rushing out to the atmosphere at the opposite side, which may explain the difference of heat conditions to which the material is subjected. It also affects the uniform circulation of the cooling agent.

An arrangement that is in use by some manufacturers provides, in cylinders of large dimensions, for two inlet and exhaust valves. This is a step in the right direction, although it does not do away with the fact that one side of the cylinder and liner gets more heat to absorb than the other, but this construction materially improves the symmetry of the casting, and incidentally makes it possible to use smaller valves which stand up better than larger ones and allow lower velocities of the gases, which also is an important point to keep in mind.

From the foregoing it may be readily understood that the cooling agent circulation is not uniform, and therefore special means of regulation have to be resorted to.

In this respect two cycle engines meet more favorable conditions whether they are designed for top scavenging

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or for port scavenging. The so-called top scavenging system of two cycle motors is apparently the most rational, because as a rule a number of valves are located in the cylinder head and so distributed that the symmetry of the casting is maintained. Furthermore, the exhaust ports located at the lower end of the cylinder are distributed equally over the whole circumference, which not only affords an ample area for expansion of the exhaust gases but also renders it possible to utilize the expanding gases to the limit.

An Advantage of the Two Cycle Motor

In two cycle engines having port scavenging only, there are no scavenging valves in the head, which materially simplified that part of the motor, which is an appreciable factor. In this case the exhaust ports cover only half of the circumference of the lower end of the cylinders, as scavenging slots are provided in the other half of the circumference. A distinct advantage of two cycle over four cycle engines, comparing actual operating conditions with the use of extra heavy fuels, is this very port arrangement for the expulsion of the exhaust gases.

When the exhaust gases pass through an exhaust valve or valves in the cylinder head, they put a severe test on the valve seats, and with this method no means are provided for clearing away any solid matter that may remain after combustion. There should remain no doubt as to the superiority of this means of scavenging for two cycle engines, as it has actually been found that the two cycle engine is not liable to suffer from gummed pistons as soon as her four cycle rival, for which the remaining substantial matter in the combustion gases in cases when improper combustion occurs is directly responsible.

It is known that the exhaust valves of four cycle engines are the ones that need the utmost care, due to the extreme heat to which they are exposed. Breakage of their respective springs occurs the more readily, as these springs are also exposed to more heat than the inlet valves. For this reason certain manufacturers have resorted to means of reducing the heat effects on the exhaust valve by introducing a special port at the lower end of the cylinder, the opening of which is controlled by an automatic valve which opens by means of the pressure of the exhaust gases that prevail near the end of the working stroke. This relieves the main exhaust valve in the cylinder head from the initial severe heat conditions, thus prolonging the endurance, and as the port described has given no trouble whatsoever in actual service, it goes to show the merits of port scavenging.

Fuel Consumption

The question may be asked, why not go the whole distance in this case by building two cycle motors from the start? This question can be partly answered by considering the economics of both types, as it is known that the fuel consumption of four cycle is better than that of two cycle motors, the difference being from 4 to 10 percent, according to the various designs, in favor of four cycle motors.

Before dwelling further on the relative merits of four and two cycle engines, it can be mentioned that both types have suffered instances of bad designs. The details of the cooling water systems, and in some cases leakage of joints and stuffing boxes, have caused great damage, because lubricating oil containing an excess of salt water loses its faculty as a lubricant, and the emulsion thus formed, which gives the mixture a milky appearance, is entirely inadequate to safeguard overheating of the rubbing surfaces. Facts of this nature have done their share to create the sceptical stand taken against the rapid introduction of heavy oil motor installations, as the reputations thus gained proved to have a long-lasting nature, notwithstanding that precautions were immediately taken to avoid this unsatisfactory feature.

Compressors

Compressors of the early days had not reached the stage of development that we can refer to at present and gave more trouble than the actual working parts of heavy oil motors. This trouble has also been eliminated, proof of which is shown by the fact that installations have been kept in continuous operation considerably longer than a month. Compressors, as applied to Diesel motors on board ship, are oversized in respect to the actual necessary delivery capacity when the motors run at full power and rated revolutions.

By determining the output of the compressors, which thus far, as a rule, have been driven directly by the main motors, consideration had to be given the fact that with the engine running slow the time element for the lift of the fuel valve was prolonged accordingly. This naturally meant a loss of injection air, which could not be entirely divided with the present arrangement and therefore required larger compressors than strictly necessary under normal conditions. Furthermore, the requirements of Lloyd's classification society are "that in case of twin screw installations either one of the main compressors shall be of such capacity that both motors can be kept running at reduced speed." This, by itself, is very desirable, but it puts a hardship on the compressors proper, as they have to be made entirely out of proportion, which does not help the problem of cooling the compressed air throughout all stages; in fact, it is detrimental and only by the selection of the right materials for all parts involved, as well as the use of the proper lubricating oil, have these drawbacks been overcome and the increased heat problems nullified.

Drainage System for Air Compressors

It was also found to be very beneficial to arrange for a thorough drainage system, particularly for the low pressure stage, whereby the moisture contained in the atmospheric air drawn into that stage from the motor room space is prevented from following its way to the other stages, thereby insuring better working conditions for all valves and facilitating the problem of lubrication by reducing the carbon formation. When the points, as referred to, are given due attention, the compressor need not be a source of trouble.

The installation of independently driven compressors has been given serious consideration, although as far as the writer's knowledge goes independent driven units are not in actual service. This principle, however, appears to be sound, as it tends toward a reduction in the size of the compressors and should prove to be of help in running the main engines at lower revolutions. This is possible because the independent driven unit can be speeded up to take care of the increase in injection air consumption at lower than normal full power revolutions of the main motor or motors. This method also tends to better relative proportions of the various stages of the compressor, thus minimizing the work on the valves by facilitating the head problems involved.

Installations Without Air Compressors

Some concerns have eliminated the air compressor entirely, which not only saves about 10 percent of the horsepower which is needed for the so-called air injection fuel

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distribution system but also does away with the consequent mechanical complication and has merits derived from simplification of the installation.

In this case the fuel oil is mechanically forced into the working cylinders under a high pressure and left to its own resources as far as the proper pulverization is concerned. It is called the solid fuel injection system. Claims made by manufacturers that have adopted this feature are very promising. Good fuel consumption is claimed, and, according to statements made, there is no difficulty in handling with good economy at all loads all kinds of oils, including those of the heavier grades.

The writer has had no opportunity personally to check these statements, owing to the fact that America has not built any heavy oil motors of this type thus far, and because she has not had the opportunity to see European-built motors working on this principle. The hope may be expressed, however, that the facts are as claimed.

It is true that no additional air is required in the combustion space formed when the working piston is in its upper dead center during the working stroke of either four or two cycle engines, as adequate oxygen is available in the compressed air proper. Claims have been advanced that the use of injection air improved the combustion, which does not seem to hold true throughout, as figures published by advocates of *solid injection* do not show poor economy, and their argument that the chilling effect of the entering high pressure air as applied to air injection type motors is not without foundation. The fact remains, however, that no all-around experience is available, and comparative data are lacking at present, as the majority of Diesel motor builders are using the air injection systems, while the solid injection system that is now claimed to be successfully applied is a patented feature.

Relative Merits of Four and Two Cycle Motors

Returning to the relative merits of four and two cycle motors, it is evident that much difference of opinion prevails. The ardent claims of four cycle advocates, particularly of those in the market with real successful motors, do not seem to carry the spirit of progress; in fact, it is my personal opinion that such claims are in some cases upheld for mere business reasons, as there can be no doubt of the actual advancement made by builders of two cycle motors, who, unfortunately, have not had such a share of the business in the early stage of the game, owing to the more difficult problems to be met in the production of two cycle motors, which in some cases have met with failure. The time has arrived when no one concerned can afford to resort to one-sided judgment, although the four cycle motor practically dominates the market at present and is able to produce wonderful records of reliability and endurance, much to the credit of the game in general.

In view of the present interest taken all over the world to promote and increase the production of heavy oil motors, which by their economy are bound to play an important part in meeting the fuel problem, it seems timely to advocate a stand of unrestricted and clear judgment as to the future course to follow, as conditions which created the demand and caused the actual development of heavy oil burning machinery across the water have greatly changed, and the greatest possible overall economy of our merchant vessels must be made our first thought.

At the time the smaller nations commenced their much appreciated development work, fuel oil especially of the medium grades was plentiful and cheap and the very heavy oils were sidetracked. There was, furthermore, no competition between motorships such as the near future will surely see, and there really was no comparison between the economies of the oil motor with its rival, the steam prime mover, on land or on the sea, the oil motor's only handicap being the more difficult design and production features seconded by the absence of sufficient experience.

Many attempts to produce reliable two cycle motors were futile, and the early lines followed were discarded for the mere reason that the way of least resistance, the four cycle principle, gave results almost from the beginning.

This policy has since been followed by the pioneers in the game, and their views were entirely justified and fortunately chosen at the time, so that the reputation of their products was thereby firmly established and holds good today.

Foreign Developments

In the meantime, Belgians, French, Italians and Swiss clung to their determination to develop the two cycle engine and have clearly demonstrated the possibilities. The world war was a great handicap to them and retarded further general development. Germany shortly before the war was also experimenting with two cycle motors, but did not accomplish as much in the marine line as the other nations mentioned. Her designs, particularly in the two cycle type of submarine engine, were duplicated under license by Americans and did not prove to be a success, so that their manufacture was finally given up. In the meantime, the Germans swung their efforts to the further development of four cycle engines with great suncess, as demonstrated by the quality of the motors driving the deadly submarines during the war. The Swiss in particular succeeded in developing their two cycle motors to a point that clearly showed that this type was not going to be counted out. Oil motors built along the general lines of construction as covered by Swiss patents were built under license in America. From actual touch with this building programme the writer may frankly state that work performed over here was a credit to the license holder and the American industry in general, as all material of the high class required for the construction of these motors, submarine heavy oil motors as they were, was produced in this country.

Today a great number of heavy oil motors of the two cycle type are performing extremely well in American submarines, and the usual troubles encountered with other designs have been eliminated. It was, therefore, clearly demonstrated that with proper design, distribution of material, etc., satisfactory results are obtainable.

These oil motors are all of the high speed types, in which the actual heat conditions which affect the lifetime of important castings are most severe, and for that reason confidence can be placed in the ability of American manufacturers.

England of late has made great strides in the development of marine oil motors and has even gone a step further by building two cycle engines of the opposed piston type.

JUNE SHIPBUILDING REPORT.—The Bureau of Navigation, Department of Commerce, reports 194 sailing, steam, gas and unrigged vessels of 251,539 gross tons built in the United States and officially numbered during the month of June. About three-fifths of this tonnage are vessels owned by the United States Shipping Board. In addition to the above, four vessels aggregating 15,537 gross tons were completed in this country during the month of June for foreign owners. From other sources than construction, seven vessels of 13,260 gross tons were added to American registry during the month.

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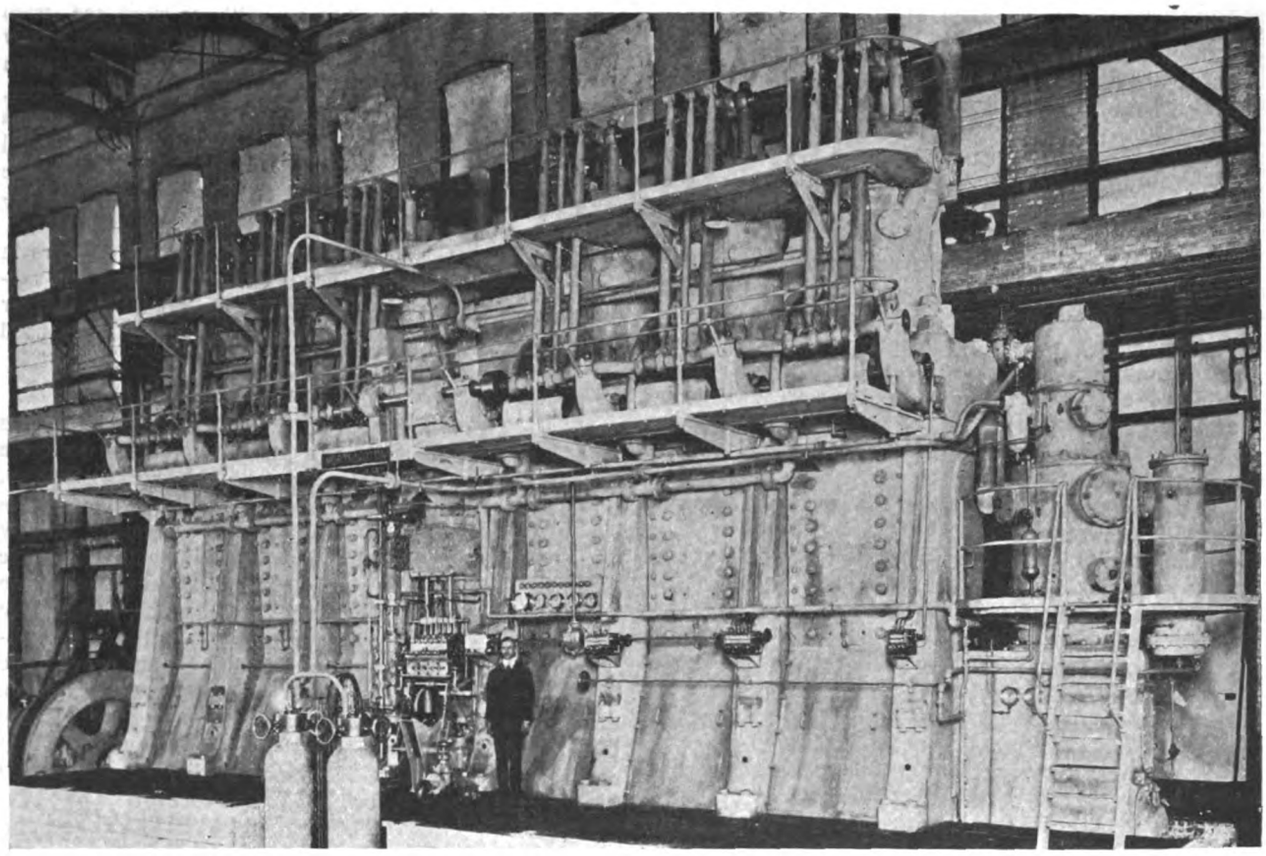

Fig. 1.—Quarter View of Worthington 2,400-Horsepower Diesel Engine from Compressor End

The Worthington Marine Diesel Oil Engine

Convinced that the best cargo vessel to-day is the motorship, provided the motorship is as reliable as the steamship, the Worthington Pump & Machinery Corporation, 115 Broadway, New York, has entered the marine Diesel engine building field and is preparing to supply complete engine room equipment for deep-sea motorships. Backing up its faith by actual deeds, this company has built at its Snow-Holly Works, Buffalo, N. Y., where for years it has been successfully producing gas and Diesel oil engines of large power for land service, a six-cylinder, four-cycle reversible marine Diesel engine, capable of developing 2,400 indicated horsepower at 120 revolutions per minute. This is the largest four-cycle marine Diesel engine so far constructed in the United States.

WITH the gradual improvement of marine Diesel oil engines, chiefly in European countries, and with the rapidly increasing fleet of motorships now successfully operated throughout the world by foreign shipowners, American engine builders have come to the realization that in order for the American merchant marine to compete successfully for overseas commerce, motorships must be added to the fleet. Without waiting for the encouragement of a definite order for motorship machinery, the Worthington Pump & Machinery Corporation, New York, has developed under the direction of Mr. W. B. Jennings, chief engineer of its Snow-Holly engine building plant at Buffalo, N. Y., plans for an American type, four-cycle marine Diesel engine and has built its first large engine of this type which is now undergoing a month's non-stop run at the builder's shop.

The engine is of the vertical single acting, reversible, four cycle, "A" frame, crosshead, marine Diesel type with six cylinders, each 29 inches diameter by 46 inches stroke, arranged in a fore and aft line. Driven from an extension of the crankshaft at its forward end is a vertical three stage air compressor. At a speed of 120 revolutions per minute the engine develops 2,400 indicated horsepower, or 1,760 shaft horsepower. The total weight of the engine, including the compressor, flywheel, thrust bearing, platform, gratings, etc., is 339¼ tons, giving a weight per indicated horsepower of 327 pounds. Its length, including the compressor, is 45 feet, and with the flywheel and thrust block, 55 feet 6 inches, while the height from the center of the crankshaft to the top of the valve gear is 23 feet 10 inches.

The handling gear is mounted on the front, or inboard, side of the engine, between frames 3 and 4. The inlet valves, exhaust valves and spray valves are located in the tops of the cylinder heads and are operated by cams secured to a camshaft fitted in bearings in brackets secured to the side of the cylinder base plate. These cams transmit motion to the valve rocker arm by means of vertical push rods. The rocker arms are supported by standards on the cylinder heads. The camshaft is driven by a train

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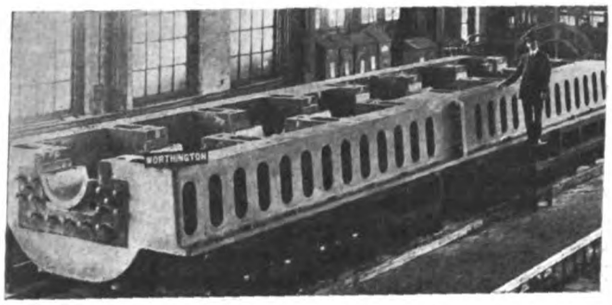

Fig. 3.—Bedplate. Weight, Each Half, 42,000 Pounds

of helical spur gears actuated from the main crankshaft.

The air starting valves are located directly under the camshaft, on the inboard side of cylinder base, with a pipe leading to each cylinder head. A spring loaded, non-return valve is placed in each line in the cylinder head.

The six fuel pumps, located in a block between columns 3 and 4, are driven by means of an eccentric on the upper gear spindle of the camshaft gear train.

BEDPLATE

The bedplate is of cast iron made in two sections, bolted together, each section supporting three cylinders. The longitudinal members on each side and the transverse members carrying the main bearings are of box section. The crank pit bottom is cast integral.

The main bearing seats are bored to receive the main bearing shells. There are eight main bearings, each having two semi-circular shells of cast iron lined with white metal and removable by rotating around the shaft. The main bearing cap is of cast iron and held down by four removable bolts. Cored openings are provided to decrease the weight in all places where the metal is not required for strength. The halves are secured by flanges and through bolts, alinement being secured by fitted bolts.

At the center of each crank pit is a hole for oil drain, all of the crank pits being connected by a pipe extending the length of the engine, underneath the bedplate. The flanges for securing the engine to the ship are drilled for a total of fifty-six 2-inch bolts.

FRAMES

The frames are cast iron of the "A" type and box section. The lower part of each leg on the side toward the

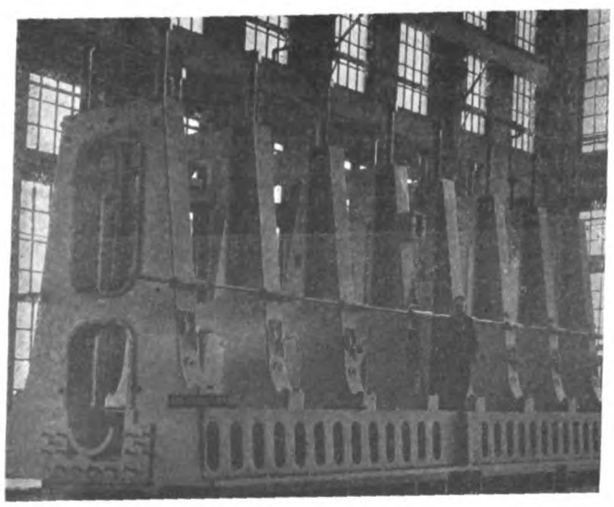

Fig. 4.—Showing "A" Frame Construction

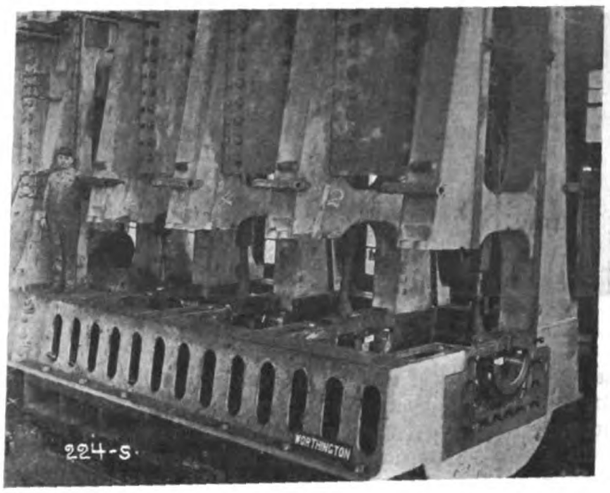

Fig. 5.—"A" Frame With Section Removed to Receive Shaft

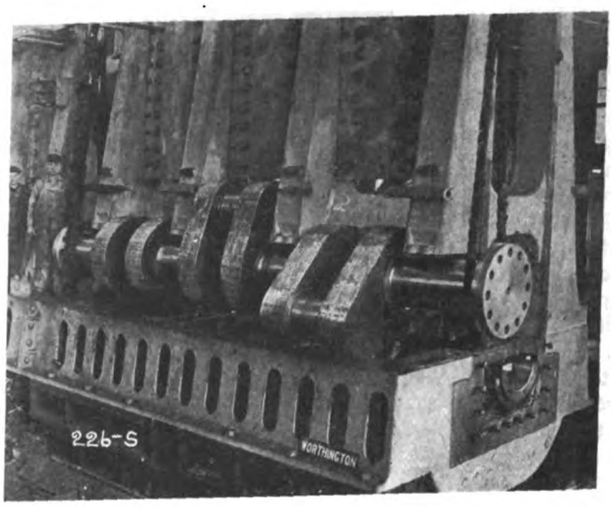

Fig. 6.—Main Shaft Partly in Frames

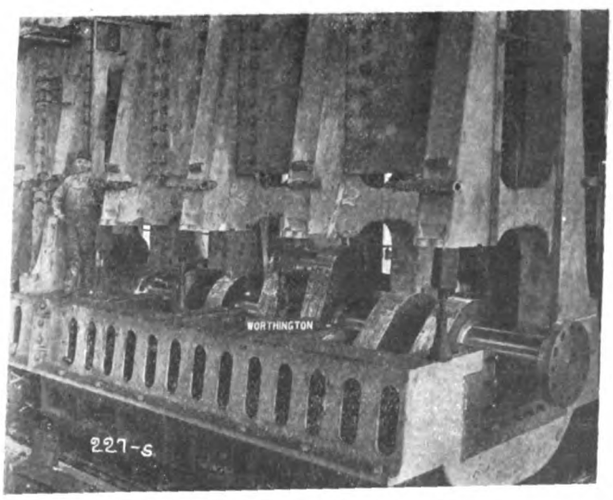

Fig. 7.—Shaft Dropped in Journals

longitudinal center of the ship is cast separate in the form of a distance piece, with machined joints, so that in the event of replacing a main shaft the distance pieces can

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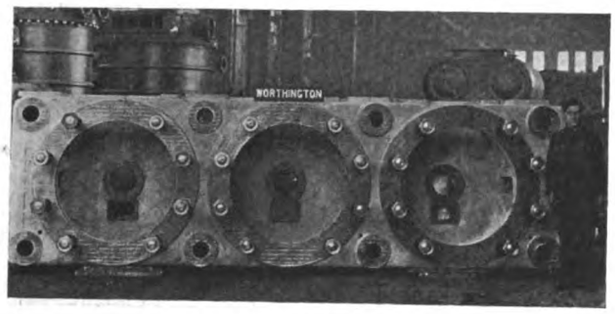

Fig. 8.—Top View of Cylinder Base Plate

be removed and the shaft taken out without dismantling the entire engine, as shown in Figs. 5, 6 and 7. The joint between the "A" frame and the loose member is made with a slight taper to facilitate its removal. When in position it is secured to the "A" frame by bolts and a key. Suitable ledges are provided on the "A" frames for supporting the crosshead guides and the splash plates.

CYLINDER BASE

Between the tops of the "A" frames and the bottoms of the cylinders is a cylinder base cast in two sections and joined by a distance piece. Each section of the cylinder base rests on four "A" frames and supports three power cylinders. Necessary strength without excessive weight is attained by a circular member surrounding the cylinder fitting-piece, from which radial ribs lead to the four bosses carrying the vertical through bolts which take the load of the particular cylinder.

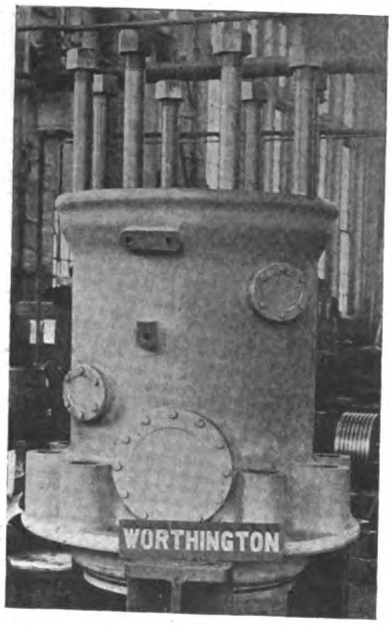

Fig. 9.—Cylinder; Weight, Including Liner, 9,000 Pounds

On the back face an opening is provided, permitting access to the piston rod stuffing box and inspection of the cylinder bore. The front face has a similar opening, making the base plate symmetrical in form.

The bottom member of the base plate is cast solid, the necessary openings for the piston rod and piston water service tubes being effectually closed against leakage. This makes it impossible for any cylinder oil or piston water leakage to pass into the crank pit and mingle with the lubricating oil.

The two sections of the base plate are joined by a distance piece provided with suitable openings for the camshaft gear. The vertical through bolts or tension rods pass through the bedplate, "A" frame and cylinder base and fit in the upper side of the bedplate and in the under side of the cylinder base for a distance equal to the diameter of the bolt. This arrangement is adopted to increase the rigidity of the structure. The bolts are of open hearth forged steel and are turned to a diameter below the root of the threads.

Each pair of tension rods passes through the bedplates close to a main bearing, so that the stress due to pressure in the cylinders is taken on the main bearing without putting the "A" frames in tension.

CYLINDERS AND CYLINDER HEADS

The power cylinders are of soft cast iron. The liner is a separate casting of hard iron, providing a durable wearing surface, the space between the liner and cylinder forming the water jacket. The liner is a close fit in the cylinder at its upper end, and the lower end is free to expand and contract with the changing temperature. The joint between the liner and cylinder at the lower end is made tight by a rubber ring which is held in place by a gland. There are four handhole plates at convenient locations in the outer wall, giving easy access to the jacket space for inspection and cleaning.

Each cylinder is secured to the cylinder base by eight bolts passing through deep lugs, symmetrically located on the circumference and joined at the bottom by a heavy flange. These bolts pass through the cylinder base and are secured by nuts under the bottom of base, thus putting the structure of the base in compression instead of tension.

Fig. 10.—Back View of Cylinder Head and Valve Assembly

Each cylinder head is of cast iron and carefully designed to secure symmetrical arrangement of the valve openings and equal distribution of the metal. The inlet and exhaust valve casings are placed on the longitudinal centerline with ample water passages around the valve space walls. The spray valve casing is placed off of the longitudinal center toward the valve gear side, and the casing wall is formed by a copper tube. This arrangement still further increases the water and core space, and assists in freeing the head from shrinkage strains.

The cooling water enters the cylinder jacket at the lower end and flows upward, passing into the head through a series of holes cored in the top face of the cylinder adjacent to the outer wall and symmetrically spaced around the circumference. A corresponding series of holes is placed in the lower face of the cylinder head. The water then passes through a hole in the top of the head into the exhaust valve casing. A relief valve is placed in the head to prevent the occurrence of abnormally high pressure.

The air supply to the cylinder is taken in through a vertical slotted pipe extending above the cylinder head.

Fig. 11.—Half Section of Main Shaft. Weight, Each Half, 41,000 Pounds

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The piston, of cast iron with concave-shaped head, is made with a central column extending from the top to the lower face and bearing against the piston rod. This serves to distribute the stress uniformly and relieve the head from carrying the entire load. There are eight Wasson piston rings, the first ring being placed as far as possible from the top face in order to remove it from the area of intense heat. The rings have beveled edges to prevent cutting and facilitate cylinder lubrication.

PISTONS AND PISTON RODS

The upper end of the piston rod is formed into a large flange and the piston rests on this flange. The rod is secured to the piston by studs threaded into the piston and fitted with lock nuts.

The piston is arranged for water cooling. The cooling water enters the head at the circumference, flowing through a cored passage to the inside of the center column. It rises in the center column, flows out through cored passages to the main body of the piston, filling this body and spreading out uniformly against the under surface of the piston head, and then is discharged through four vertical pipes spaced around the circumference of the piston and connecting with a circular passage at the bottom of the piston from which the water flows to the discharge pipe. The upper ends of the vertical pipes are close to the under surface of the piston head to insure the piston being full of water at all times and to prevent air pockets.

The piston rod, of open hearth forged steel, is flanged at the upper end to approximately the diameter of the cylinder bore, in order to distribute the load over the piston area. The rod is reduced in diameter where it passes through the crosshead, so that a large shoulder is formed which rests on the crosshead. The reduced portion of the rod passes through a hole in the crosshead and is threaded at its lower end to receive a nut for securing the crosshead tightly to the rod. This nut is slotted to receive a key spanner for screwing and unscrewing. Where the rod passes through the bottom of the cylinder base it is packed with metallic packing to prevent cylinder oil or water from leaking into the crank pit.

CONNECTING ROD AND CROSSHEAD

The connecting rod is of open hearth forged steel, of standard marine design, with forked crosshead end and with a "T" head at the bottom for stepping on the crankpin box. The rod is hollow and the axial hole is utilized for supplying oil to the crosshead pins. The crank and crosshead pin boxes are of cast steel lined with high grade white metal. The two halves of the crankpin box are interchangeable, so that when the upper half has worn it may be replaced by the bottom half.

The crosshead is of open hearth forged steel. The body consists of a square forging, bolted to the cast steel slipper. Projections fore and aft from the body form the crosshead pins for receiving the boxes of the forked connecting rod. The cast steel slipper is secured to the crosshead body by through bolts and its surfaces are faced with white metal. The backing surface is approximately two-thirds that of the ahead surface. Diagonal holes are drilled through the slipper, through which oil from the ahead guide may flow to the backing guide. The body of the crosshead is bored to receive the reduced portion of the piston rod end. The usual tapered fit at this point is not necessary, as the greatest upward pull is slight compared with the downward thrust.

The crosshead slipper runs on a water cooled guide. The crosshead guide is of cast iron, of box section, and is secured to flanges on the "A" frames. As the principal thrust comes on the inboard side of the engine, the guides are placed there. While running astern, the thrust is taken by backing strips, secured to the main guide by through bolts.

CRANKSHAFT AND THRUST

The crankshaft, of open hearth forged steel, is built up in two sections, each section having three cranks. Each crankpin is forged integral with two webs. The main bearing sections are secured to the cranks by shrink fits and keys. The two sections of the shaft are interchangeable and are fitted together by flange couplings fitted with taper bolts.

The thrust shaft forms an extension on the aft end of the crankshaft and is secured to the latter by a flanged coupling and bolts. It is carried in a base which is secured to the aft end of the bedplate and to the ship's members. The thrust bearing is of the Kingsbury type.

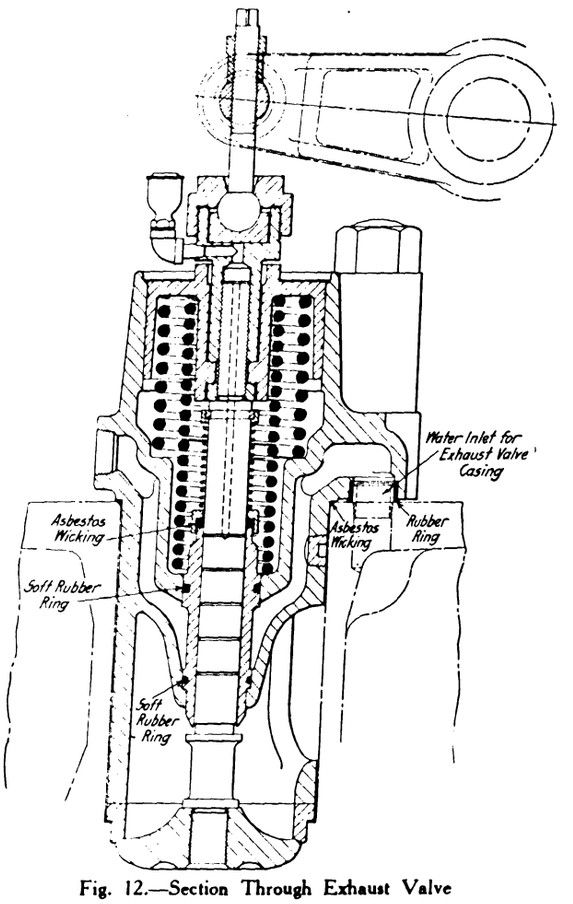

Fig. 12.—Section Through Exhaust Valve

Immediately aft of the thrust shaft bearing and located on the thrust shaft is a flywheel cast in halves, bolted and keyed to the shaft and secured at the rim by shrunk keys. All the flywheel load is thus taken off the aft main shaft bearing and the tendency of that bearing to wear reduced. The flywheel has teeth cast in its rim which engage with the worm on the turning engine shaft.

VALVES AND VALVE GEAR

The inlet and exhaust valves are symmetrically placed on either side of the center of the head and are interchangeable, as the casings and valves are duplicated throughout. This makes it necessary to carry but one set of spares. The valve disk is of cast iron; the stem is of forged steel and is threaded into the disk with the end riveted over. The stem is made of large diameter in order

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to promote rapid heat transfer. The valve seat is formed on a ring separate from the valve cage so that the seat can be readily renewed, if necessary, without renewing the complete cage. The joints between the valve cage, valve seat and cylinder head are flat, so that in setting up for tightness no splitting stresses are set up in the head, as would be the case with tapered joints. The valve seat is of cast iron and both the valve and valve seat are cast in a chill and finished by grinding.

Attached to the upper end of the valve stem is a cylindrical guide of large diameter, which is housed in a bored extension of the valve casing and which maintains the alinement of valve and stem. The lower part of the valve stem is further guided by a long, removable, cast iron bushing, at the upper end of which is a stuffing box and gland to prevent the lubricating oil being blown out by the exhaust pressure. This gland is held in place by a coil spring which bears against the lower end of the valve stem guide. This spring is compressed when the valve is opened, so that the maximum pressure against the packing is exerted only when the exhaust gases are passing through the valve. The valve cages are provided with a water jacket, but water is used only in the exhaust valve cage. The joints between the removable bushing and the valve cage body are made tight against water leakage by soft rubber rings held in circumferential grooves.

The bearing surface of the valve stem, where it is guided by the removable bushing, is provided with circumferential oil grooves and lubricating oil is supplied through an axial hole from an oil cup on top of the stem.

The pin by which motion is transmitted from the valve lever to the valve is attached to the upper part of the valve guide by a ball and socket joint. The valve springs are two in number and are supported on the lower part of the casing and bear against the under side of the valve stem guide, which is made cup-shaped to receive them.

A combined spring compressor and lifting device is provided by which a complete valve and cage assembly may be easily removed from the cylinder head and disassembled on the work bench.

Auxiliary Exhaust Valve a New Feature

At the lower end of the cylinder is an auxiliary exhaust valve in communication with a port in the cylinder liner which is uncovered by the piston near the end of its stroke. The valve is self-contained in a water-jacketed casing which is readily removable and is fitted with a dash pot which prevents pounding of the valve in either direction. A jacketed pipe connects each casing with the main exhaust pipe.

The valve is normally held on its seat by a spring, but when its port is uncovered by the piston at the end of its stroke the pressure inside the cylinder overcomes the resistance of the spring and the valve opens, permitting the hot gases in the cylinder to discharge into the exhaust line. When the piston moves upward on its return stroke it covers the port and the valve is seated by the spring pressure acting behind it. The gases that are left in the cylinder at low pressure are then forced out through the main exhaust valve in the usual way. By this means the first and hottest portion of the exhaust gases are discharged through the auxiliary valve, thus relieving the main exhaust valve of this duty, prolonging its life and requiring less frequent grinding of valve and seat.

When starting the engine with air the auxiliary valve relieves the pressure at the end of the stroke before the main valve opens and thus relieves the exhaust valve operating gear of a large part of its load.

Spray Valve

The fuel spray valve is a steel, long stem, disk valve working through a long guide and stuffing box on a conical seat. The valve body is in four main parts. The outer tube fits in the copper casing through the cylinder head and its lower end is provided with a square shoulder that makes a joint on a flat seat at the bottom of the opening

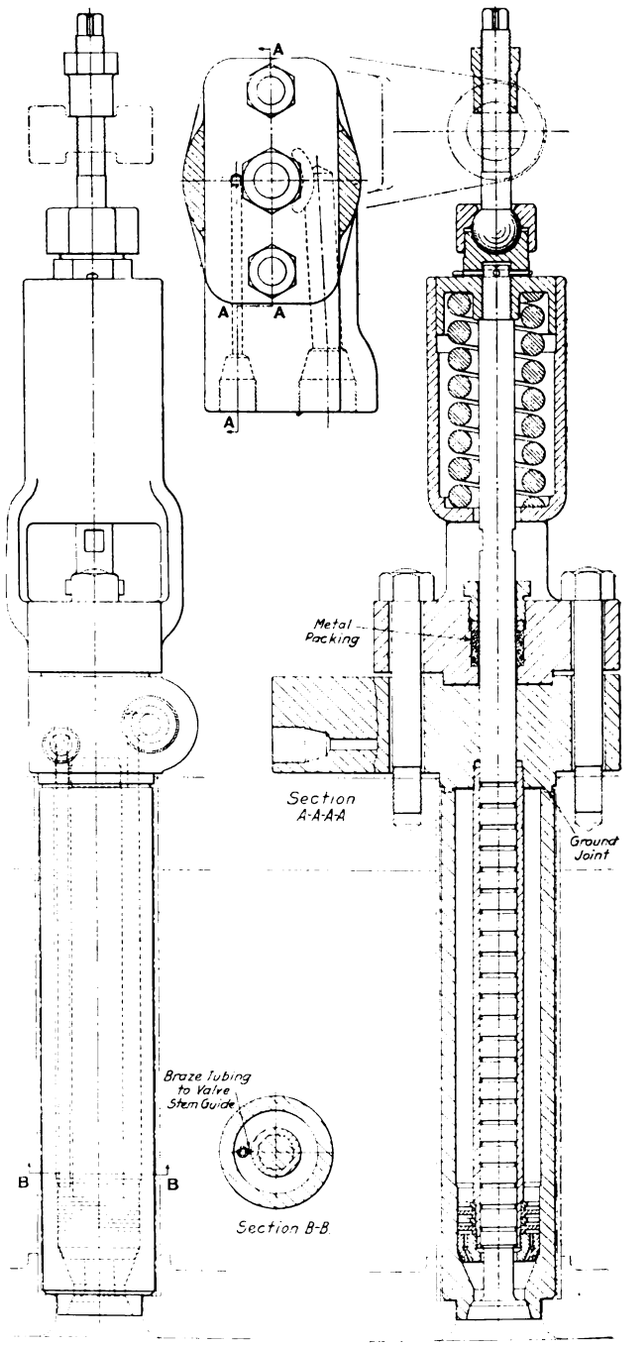

Fig. 13.—Details of Spray Valve

through the head. This joint is made tight with a McKim gasket. The inner tube, which forms a guide for the valve stem, is concentric with, and smaller in diameter than, the outer tube, so that there is an annular space between the two. The inner tube is accurately centered in the outer tube by means of the pulverizer rings at its lower end and a cover block into which its upper end is threaded. This cover block seats on top of the outer tube with a male and female ground joint. It contains the drilled pas-

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sages through which fuel oil and spray air are admitted into the valve body.

Seated on top of the cover block, with a McKim gasket, is the valve cover, which is bored and threaded for a packing gland where the valve stem passes through. This valve cover is extended at the top to form a spring cage which is bored at its upper end to receive a cylindrical guide of large diameter. This cylindrical guide is threaded on the upper end of the valve stem. It guides the valve stem and its under side acts as a bearing for the valve spring.

The valve has a cone seat and the oil spray is discharged into the cylinder in the form of a diverging cone. The pulverizer through which the oil is forced before passing through the valve consists of a series of thin disks placed one on top of the other in the annular space between the inner and outer tubes and separated by small shoulders around their inner peripheries. Each disk contains a number of thin, radial slots and the disks are so placed that the slots are staggered, thus forming a tortuous path for the oil.

Extending downward in the annular space between the inner and outer tubes, from the oil passage in the cover block to a point just above the upper disk, is a vertical pipe which deposits the fuel oil on the top of the upper pulverizer disk. The annular space communicates with the air passage in the cover block, so that it is always filled with air under a pressure of 800 to 1,000 pounds per square inch. The oil spreads out over the surfaces of the disks, and when the valve is pushed open by the valve lever the high pressure air rushes through the pulverizer disks and sweeps the oil into the cylinder in a finely divided form.

The valve stem at its upper end is attached to the valve lever by means of a ball and socket joint similar to that described with the inlet and exhaust valves. The complete valve assembly is held in place by two stud bolts which pass through the valve cover and cover block and screw into the cylinder head.

Air Starting Valves

The air starting valves, one for each cylinder, are attached to the inboard side of the cylinder base, adjacent to the camshaft bearings and beneath the camshaft, the valve being directly under the centerline of the camshaft. The air starting cam acts directly on a roller in the end of the valve stem, no levers or reach rods being required. The valve is of the mushroom type, with the stem enlarged to form a guide. Normally the valve is in its bottom position and open. In this position the roller on the end of the stem does not make contact with the cam.

When the starting air is turned on from the operating platform, the pressure raises the valve to its seat and holds it firmly closed, or brings the stem in contact with its cam, depending on the position of the latter. The valves are then in position to be operated by the camshaft. The starting air is discharged into the cylinders by means of a short pipe connection between the starting valve and the check valve on top of the cylinder.

Valve Levers and Push Rods

The inlet, exhaust and spray valves are operated by cast steel levers mounted on fulcrum shafts which are carried by two stanchions secured to each cylinder head. With this arrangement the valve driving gear is independent for each head, permitting renewal without disturbing its alinement. As previously noted, the connection between each valve and its lever is by means of a ball joint.

The motion from the cams to the valve levers is transmitted through push rods of seamless drawn steel tubing with solid steel ends shrunk in. The lower ends are forged and carry the cam rollers on pins of ample dimensions. The location of the air starting valves under the cam shaft instead of on the cylinder head eliminates one push rod and valve lever at each cylinder. Space is thus provided for extra large cam roller pin bearings, reducing wear and noise. The push rods are guided at their lower ends by links pivoted on the reverse shaft cranks.

The camshaft is carried in brackets supported on the side of the cylinder base plate, each bracket containing a bearing formed of two die cast half shells of bearing metal with adjustable caps. The shaft is in three sections, a middle one upon which the driving gear is mounted, and two end sections each carrying the cams

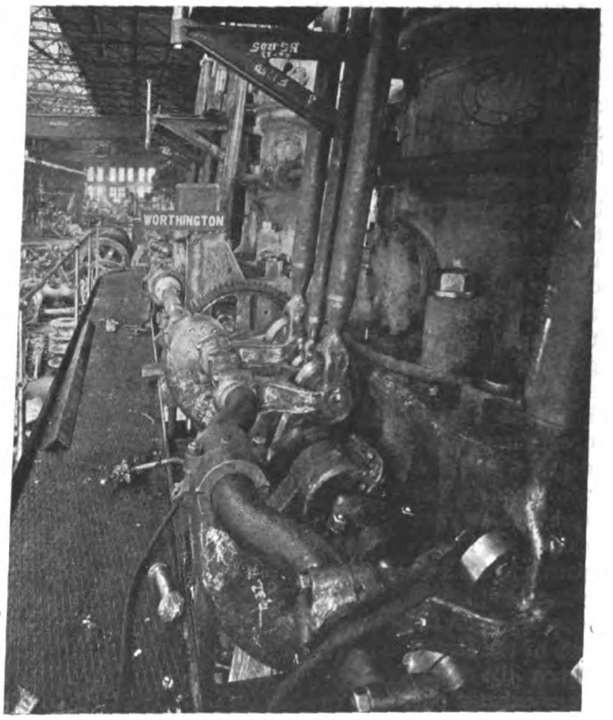

Fig. 14.—View from First Platform, Showing Valve Gear

for three cylinders. Flange couplings joining the two end sections to the middle sections are placed on either side of the two center bearings.

Camshaft and Cams

The camshaft is driven from the main shaft by a train of helical cut spur gears, located at the center of the engine. The first gear is mounted on the main shaft coupling and is in halves bolted together. Following are two idler gears running on shafts which are clamped to brackets supported on the adjacent "A" frames. The next gear is carried in a similar manner and has bolted to it the half speed gear with which the gear on the camshaft meshes. The brackets supporting the gear shafts rest on adjustable studs by means of which the gears can be brought into correct mesh.

The spray valve cams are adjustable for timing the injection of fuel. This adjustment feature is secured by making each spray cam in two parts. A small flange is keyed rigidly to the camshaft and the cam is mounted on this flange, being secured to it by bolts. The bolt holes through the cam are slotted, so that the cam may be rotated on the flange. Two lugs project from one side of the

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cam, and threaded through these lugs are set screws whose ends bear against the opposite sides of a lug projecting from the side of the rigid flange. The cam is rotated on the flange for adjustment by screwing out one set screw and screwing in the other. When correct adjustment is secured both set screws are set up tightly and the nuts on the securing bolts are tightened, thus securing the cam rigidly in position.

Taking the cams of one cylinder in the order in which they operate, the succession is as follows:

Five degrees before top center the spray valve is opened by its cam, which holds it open through the first 49 degrees of the down stroke, thus keeping the valve open through 54 degrees of a revolution. The spray valve then closes and expansion takes place until 138 degrees from the top of the stroke, when the auxiliary exhaust port is uncovered by the piston and the auxiliary exhaust valve opens.

At 6 degrees before the bottom center the main exhaust valve is opened by its cam. The auxiliary exhaust valve closes at 42 degrees past the bottom center, but the main exhaust valve is held open by its cam until 14 degrees after the top center, or through 200 degrees of a revolution of the crankshaft.

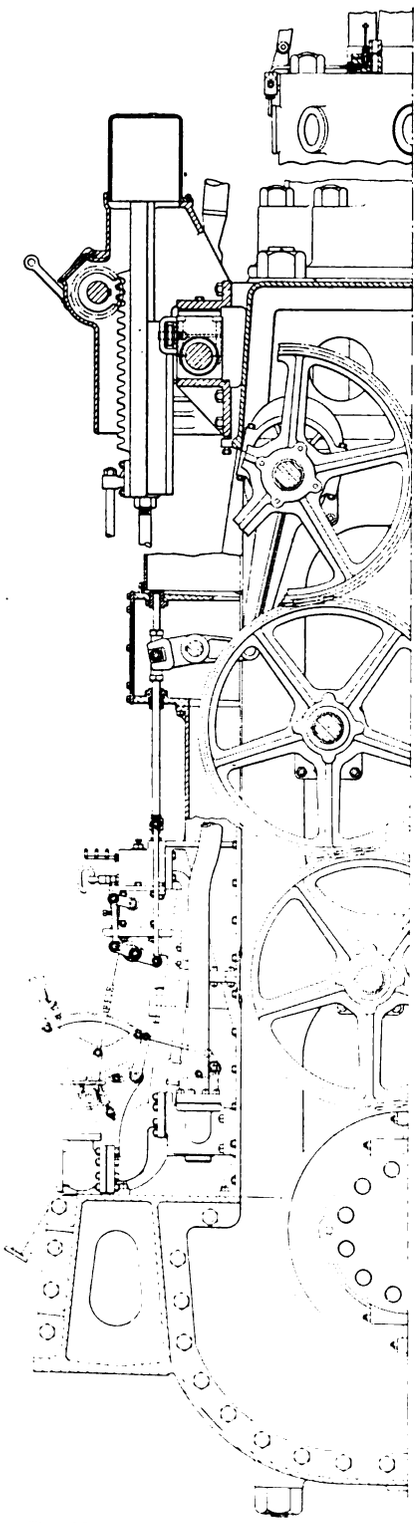

Fig. 15.—Operating Gear, Side View

At 22 degrees before the top center, on the upward stroke of the piston, the inlet valve opens and is held open by its cam during the whole of the down stroke of the piston and until 34 degrees past the bottom center, or through 236 degrees of a revolution. Compression then begins and is maintained until 5 degrees before the top center, when the spray valve is again opened and the cycle begins again.

It will be noted that the inlet and exhaust valves are open at the same time during 36 degrees of a revolution. The reason for this is that at this point the exhaust gases are flowing rapidly out through the exhaust valve and the cylinder volume is decreasing very slowly, due to the slight motion of the piston at this point in the stroke. The inertia of the exhaust gases maintains their flow after they have ceased to be acted upon by the piston, thus creating a depression of pressure in the cylinder which helps to start the flow of fresh air into the cylinder through the inlet valve.

The air starting valves and cams are in operation only when the engine is being started. These valves open at 2 degrees past the top center and close at 130 degrees, being open during 128 degrees of a revolution. The order of firing is No. 1, 5, 2, 6, 3, 4 ahead and No. 1, 4, 3, 6, 2, 5 astern.

Method of Reversing the Engine

The reverse shaft is of forged steel and extends parallel to and inboard of the camshaft, being carried in babbitted bearings on the same brackets that support the camshaft. It is formed with cranks opposite each cylinder on which are pivoted the guide links, which are attached to the lower ends of the valve push rods. These guide links serve the double purpose of guiding the push rods and pulling the rollers out of the area of contact with the cams when reversing.

There are two sets of cams on the camshaft, and reversing is accomplished by sliding the camshaft, bringing the second set of cams under the rollers. The construction and operation of the reversing mechanism is as follows:

The camshaft carries a block which slides on a bearing secured to one of the center "A" frames and which carries rollers engaging a cam plate, straight for a portion of its length at each end and curved in the center. This latter is attached to the piston rod of an air cylinder mounted on the "A" frame leg. Secured to the piston rod and adjacent to the cam plate is a rack which engages a pinion on the reversing shaft. When the air is admitted to the operating cylinder the pinion begins to rotate and pulls the cam rollers out of the area of contact with the cams. During this movement the straight part of the cam plate is passing the rollers on the camshaft block, so that no longitudinal motion of the latter takes place. As soon as the cam rollers are pulled out of area of contact the curved portion of the cam plate engages the camshaft block and the camshaft is shifted, bringing the second set of cams under the rollers. The remainder of the air cylinder stroke completes the revolution of the reverse shaft and brings the roller back onto the cams. During this period the other straight end of the cam plate is in contact with the rollers so that no movement of the camshaft takes place.

Above the air cylinder is an oil cylinder by means of which the rapidity of movement of the gear can be controlled and shocks prevented.

Operating Gear

The main control of the engine is by two levers, one for the forward three cylinders and the other for the aft three. These levers are located side by side at the center of the length of the engine and are operated from the engine room floor. The first movement of either lever admits the starting air, and further movement closes the

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air and admits the fuel oil, continuing movement increasing the amount of oil up to maximum load. Separate control of each three power cylinders makes possible a lower minimum speed, as by operating on one-half of the cylinders the power developed per cylinder is doubled, insuring regularity in burning of fuel and increasing the flexibility of the engine.

For reversing, a lever is located to the left of the main operating levers and adjacent to the reversing air cylinder. This lever controls two mushroom valves which admit air to either end of the reversing cylinder, which is completely interlocked with the main operating levers so that it is impossible to shift the reverse gear when either the starting air or fuel is on, or start the engine with the reverse gear off of either ahead or astern position. A bar

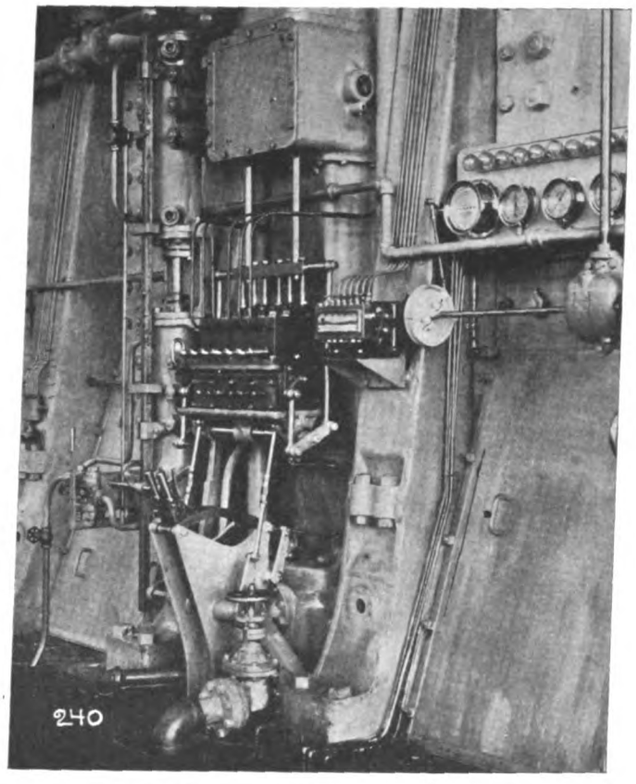

Fig. 16.—Fuel Pump and Operating and Reversing Gear

connected to the air cylinder piston rod serves to return the reverse lever to mid position near the end of the stroke in either direction, shutting off the air from the cylinder, and at the same time to release the lock on the main operating levers, permitting of starting of the engine. There is also a valve at the operating station which controls the main starting air supply and which is closed when maneuvering is completed.

The main supply line from the storage tanks leads to a casing at the operating station containing two valves, each connected to one of the operating levers and controlling the air to three power cylinders. From each one of these valves a pipe extends upward and then along the cylinder base in each direction, supplying the air to the operating valves. From the latter, separate pipes lead to the cylinder heads where suitable check valves are located. The air pressure for starting and maneuvering is 375 pounds per square inch.

The compressor for furnishing the spraying and starting air is located at the forward end of the engine and is driven from a crank on the end of the main shaft. The compressor cylinders are arranged tandem and are supported on a housing which rests on the ship members and is bolted to the engine base and forward "A" frame.

AIR COMPRESSOR

The compressor is of the three stage type, the second stage being obtained by a differential piston. The first and third stage discharge occurs on the up stroke and the second stage on the down stroke. An extension of the piston carries the wrist pin and forms a crosshead which runs

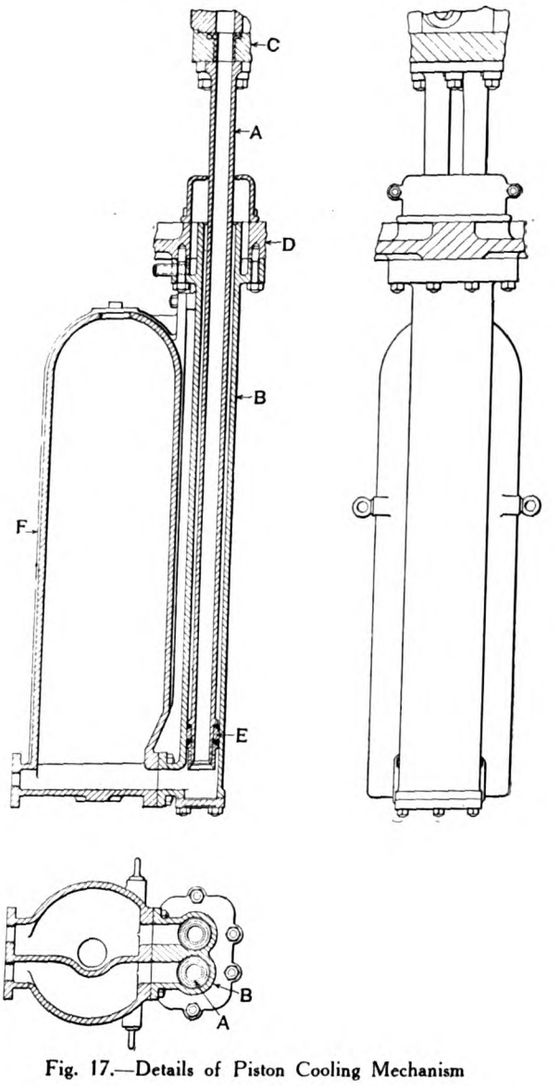

Fig. 17.—Details of Piston Cooling Mechanism

in a bored guide in the compressor housing. The cylinders are cast with double walls, the space between forming the water jackets. Removable liners are fitted to all of the cylinders, providing durable wearing surfaces for the pistons. There are two cylinder castings, the lower one resting on the housing, containing the first and second stage, and the upper one the third stage.

Laidlaw feather valves (patented) are used for both suction and discharge on all stages, insuring freedom from valve trouble. There are two suction and two discharge valves each on the first and second stages and one each on the third stage. The discharge valves throughout are water jacketed to prevent excessive temperature and consequent carbonizing of the lubricating oil.

The valve seat is a cast iron grid of disk form, the slots through the grid forming the air passage and the

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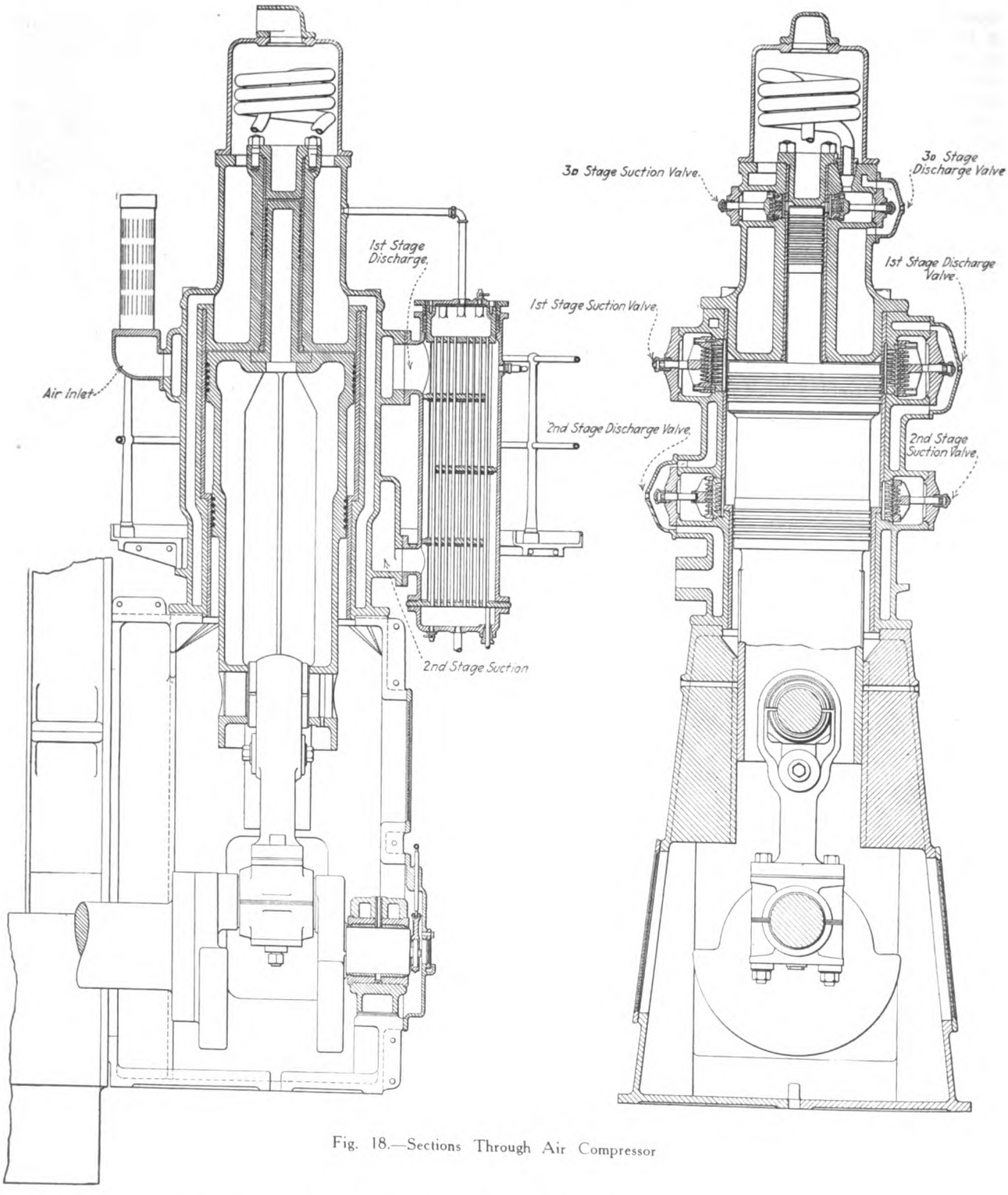

Fig. 18.—Sections Through Air Compressor

bars forming the seat for the valve strips. Seating on top of the grid and covering the slots are thin, flexible strips of steel, held in place by a second disk grid resting on top of and bolted to the first grid, in such a position that the bars on the second grid coincide with the slots in the first grid. The bars of the second, or cover grid, are milled out to a concave shape, so that when pressure comes under the valve strips they are free to bend or bow upward, thus making a passage for the air to flow through. When the excess of pressure under the valve strips ceases they straighten out and seat firmly on the flat topped grid. The ends of the valve strips, when the center lifts, remain in contact with the seat, so that the closing of the valve strips, instead of being an impact, becomes merely an increase in the point of contact. The whole valve unit fits into a cone-shaped opening and is held in place by a single stud through the valve bonnet. The intake and discharge valves are identical and interchangeable.

The compressor is of ample capacity to provide spraying air for the engine when operating at a minimum speed, and to fill the maneuvering air tanks and supply the spraying air at full speed. In order that the compressor may operate efficiently at full speed when a minimum amount

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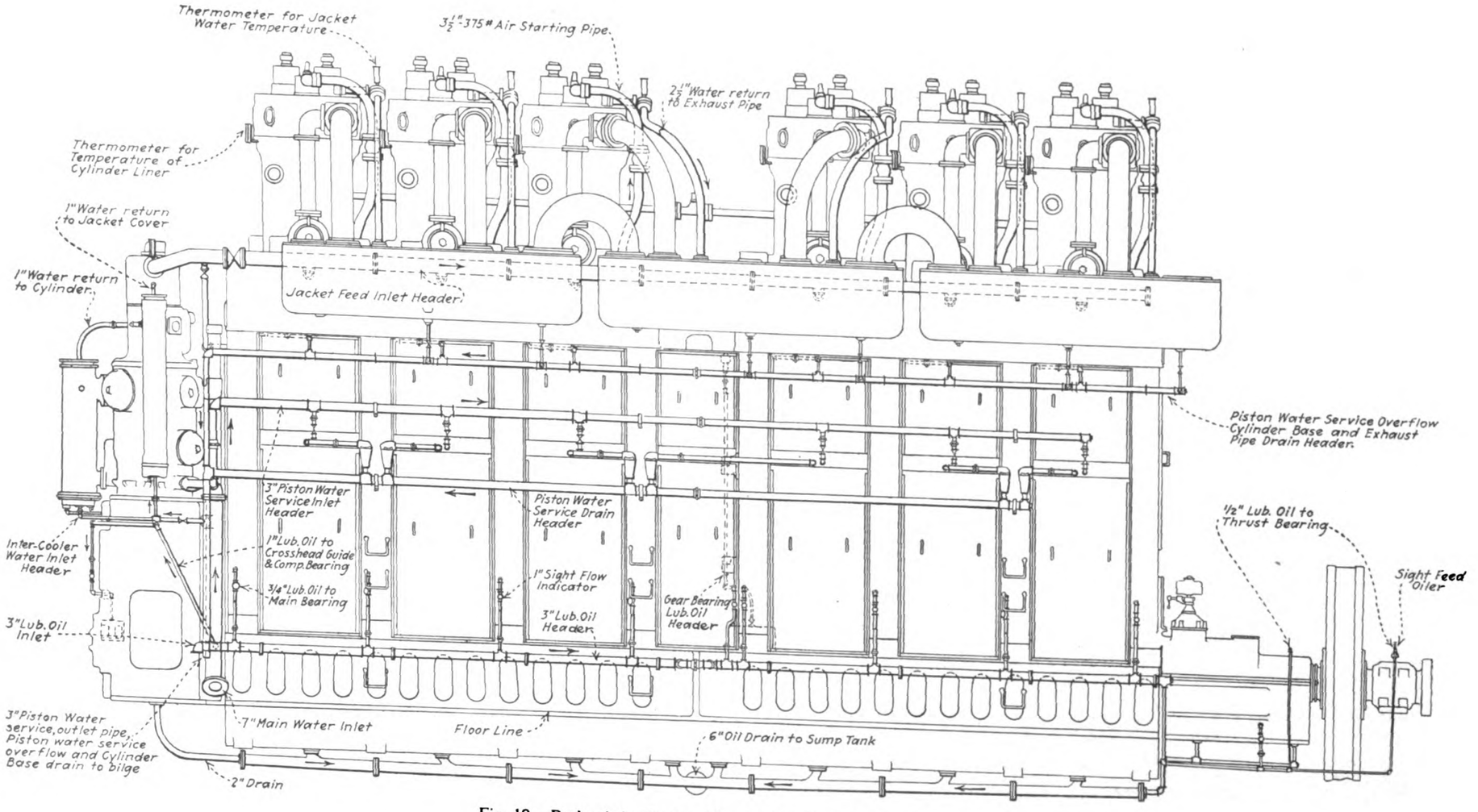
Thermometer for Jacket Water Temperature
3½"-375# Air Starting Pipe
2½" Water return to Exhaust Pipe
Thermometer for Temperature of Cylinder Liner
1" Water return to Jacket Cover
1" Water return to Cylinder
Jacket Feed Inlet Header
Piston Water Service Overflow Cylinder Base and Exhaust Pipe Drain Header
3" Piston Water Service Inlet Header
Piston Water Service Drain Header
½" Lub. Oil to Thrust Bearing
Inter-Cooler Water Inlet Header
1" Lub. Oil to Crosshead Guide & Comp. Bearing
1" Sight Flow Indicator
Sight Feed Oiler
¾" Lub. Oil to Main Bearing
Gear Bearing Lub. Oil Header
3" Lub. Oil Inlet
3" Lub. Oil Header
3" Piston Water service, outlet pipe, Piston water service over flow and Cylinder Base drain to bilge
7" Main Water Inlet
Floor Line
6" Oil Drain to Sump Tank
2" Drain

Fig. 19.—Back of the Engine, Showing Details of Piping Arrangement

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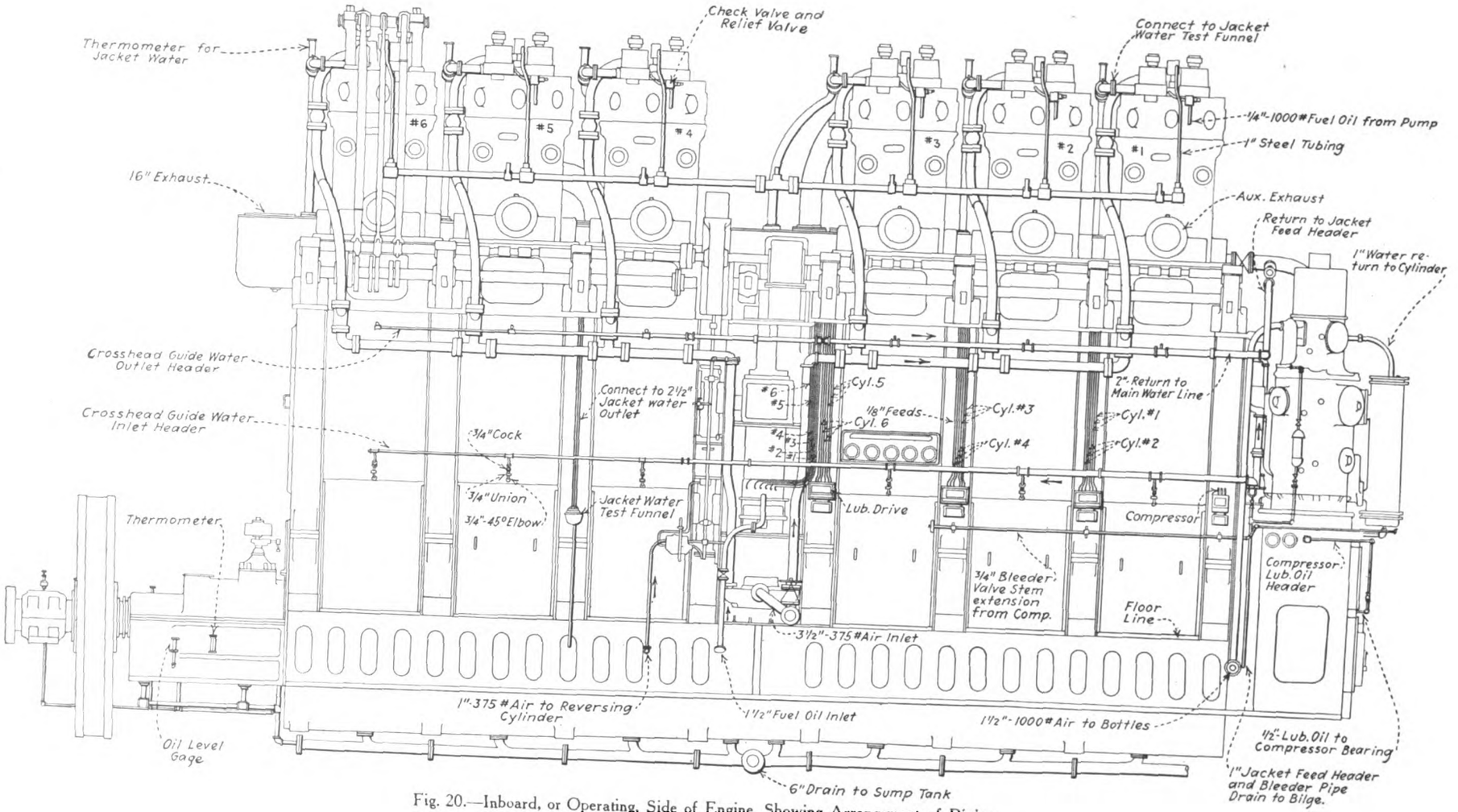

Fig. 20.—Inboard, or Operating, Side of Engine, Showing Arrangement of Piping

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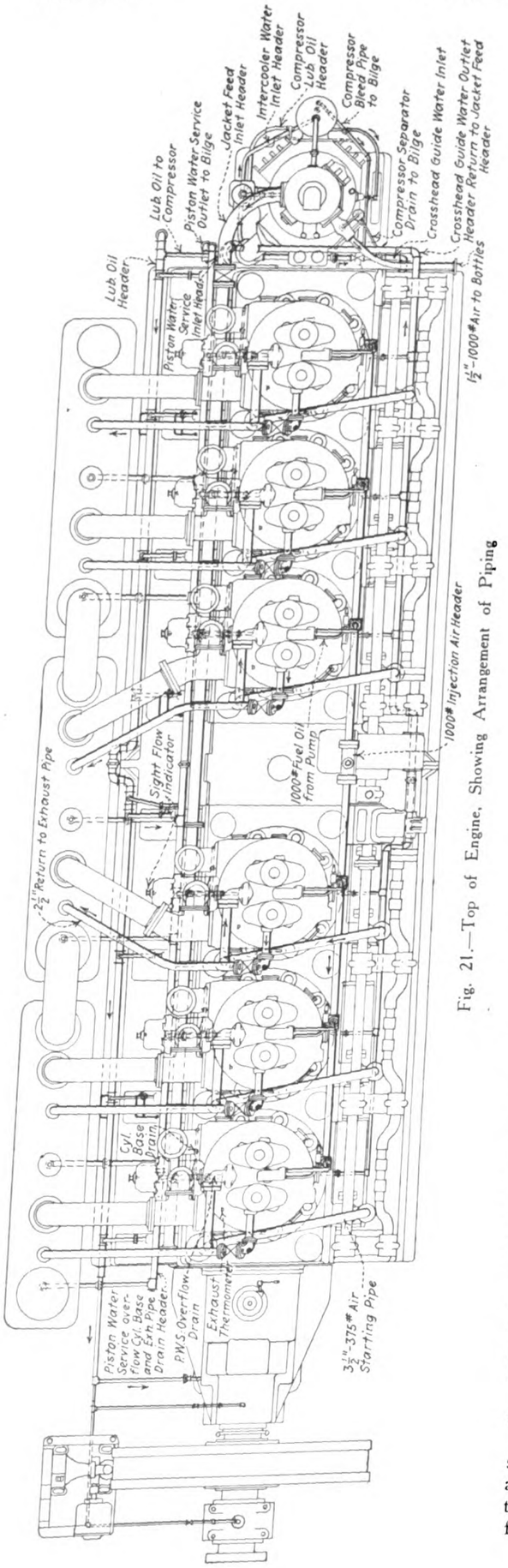
Lub Oil to Compressor
Piston Water Service Outlet to Bilge
Jacket Feed Inlet Header
Intercooler Water Inlet Header
Compressor Lub Oil Header
Compressor Bleed Pipe to Bilge
Compressor Separator Drain to Bilge
Crosshead Guide Water Inlet
Crosshead Guide Water Outlet Header Return to Jacket Feed Header
Lub Oil Header
Piston Water Service Inlet Header
1½"-1000# Air to Bottles
1000# Injection Air Header
1000# Fuel Oil from Pump
Sight Flow Indicator
2½" Return to Exhaust Pipe
Cyl. Base Drain
Piston Water Service Overflow Cyl. Base and Exh. Pipe Drain Header
P.W.S. Overflow Drain
Exhaust Thermometer
3½"-375# Air Starting Pipe

Fig. 21.—Top of Engine, Showing Arrangement of Piping

of air is required, a valve is provided which bleeds the first stage discharge air into the bilge and which is closed when the maximum capacity is needed. This valve is controlled from the main operating stand.

GOVERNOR

A centrifugal, spring loaded governor is located just forward of the thrust bearing and is driven from a ring gear attached to the forward thrust shaft coupling flange. This governor serves as a safety stop only, cutting off the fuel oil supply from five of the six cylinders when the speed increases about 10 percent over normal. This control is omitted from the sixth cylinder in order to prevent the possibility of stalling the engine when the governor acts.

The governor acts through reach rods and a shaft to operate a bar which lifts the rocker arms beneath the suction valves of the fuel measuring pumps, holding the valves open during the entire discharge stroke.

FUEL OIL SYSTEM

Fuel oil is drawn from the main storage tanks by an independent motor driven pump, from which it is forced to the gravity tanks from which it flows to the suction chamber of the fuel measuring pumps.

The six working cylinders are provided with individual measuring pumps. These are contained in a single unit mounted on the inboard side of the engine between "A" frames 4 and 5, directly above the operating platform. The six vertical, single acting plungers are driven in unison by a single bar which receives its motion from a small walking beam mounted in a box directly above the pump unit. This beam receives its motion through an eccentric arm from an eccentric mounted on the spindle of the upper gear of the camshaft gear train. The pump driving bar is located above the pump plungers and the plungers are attached to it in such a manner that any one plunger can be removed without disturbing the others.

PIPING

The piping on the engine may be divided into six systems, namely, air starting, spray air, fuel oil, cooling water circulation, lubricating oil and exhaust.

Air Starting System. The starting air is supplied to the engine from the starting air tanks, which are kept filled to 375 pounds pressure by by-passing some of the air from the main engine air compressors, or which can be filled by an auxiliary motor driven compressor. The starting air from the tanks passes through a stop valve at the tanks, through the main supply pipe to the operating station on the inboard side of the engine, and through a stop valve to a casing just behind the operating levers. This casing contains two piston valves, each valve connected to one operating lever by reach rods and bell cranks. From each valve an outlet pipe leads up to the level of the starting valves, then along the inboard side of the engine, each pipe supplying the starting air for three cylinders.

When standing by for maneuvers the stop valves are open and the starting air is up to the control valves in the casing. When maneuvering is completed and the engine is in operation the stop valve at the operating station is closed.

In port, where the engines are not to be used for some time, the stop valve at the tanks should also be closed.

Spray Air System. Spray air is supplied from the spray air flasks located near the operating station. Air at 1,000 pounds pressure is pumped into these flasks from the main engine air compressors, or they may be supplied from the motor driven auxiliary compressor. While the

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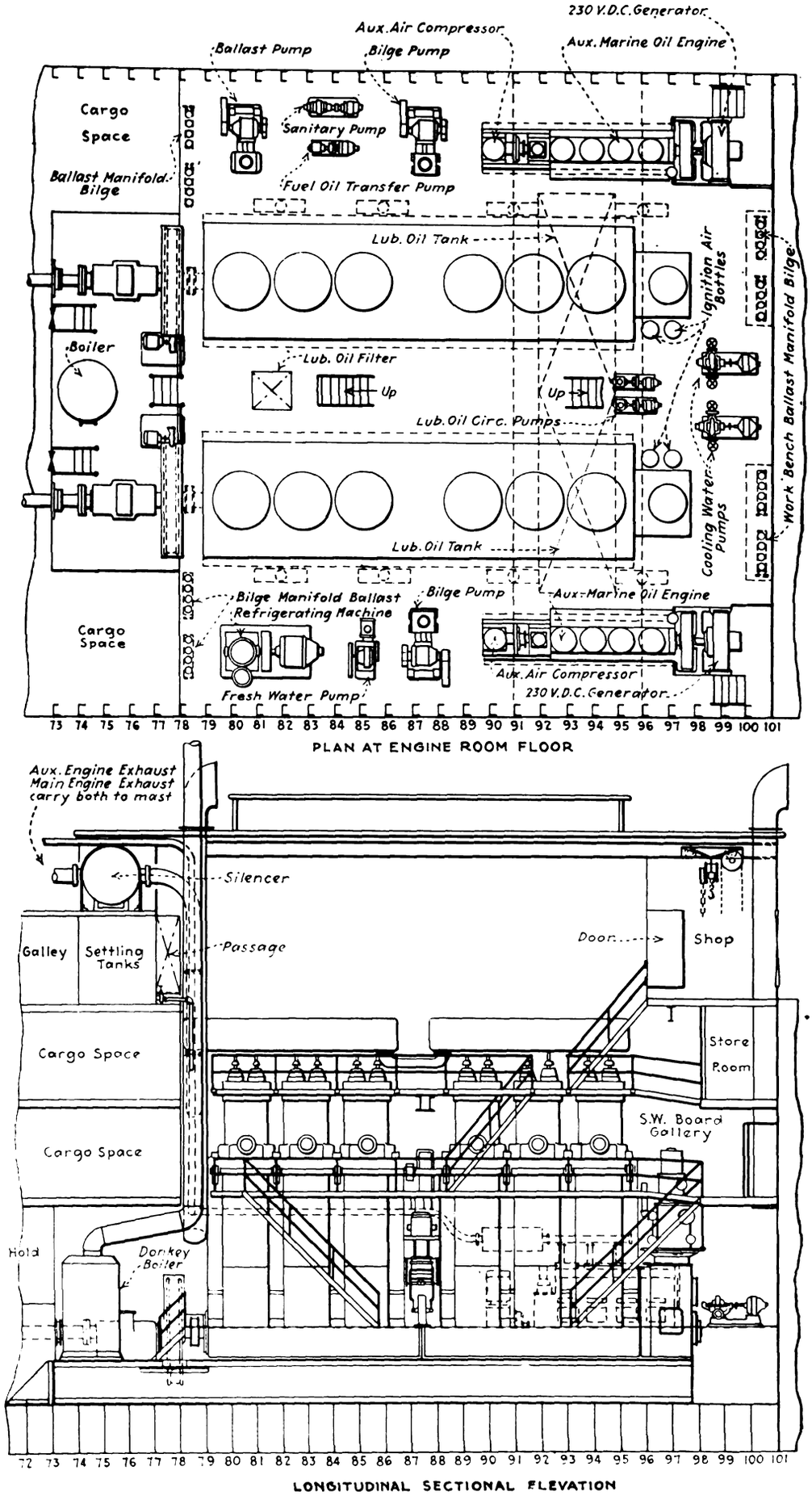

Fig. 22.—Plan and Longitudinal Sectional Elevation of Engine Room for Proposed Twin-Screw Vessel Equipped With Worthington Diesel Engines and Auxiliaries

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engine is running, one spray air flask is in series with the air compressor so that the air is supplied to the engine from the compressor and the flask tends to reduce any fluctuations in pressure. The second flask is in reserve and cut out. At the point where the discharge line leaves the header a separator is installed in the line for removing oil and water from the air.

At the inlet to each air flask is a 1-inch pressure relief valve which is always in communication with the air line from the compressor, whether the stop valve at the air flask is closed or open. The outlet from each flask is provided with a stop valve so that the flasks may be charged while air is shut off the engine. An opening for connecting a pressure gage is provided in the top of each flask and closed by a valve. All valves on the flask are provided with double seats so that when the valve is wide open no leakage can occur around the stem. The inlet opening to the flask is extended down to about one-half the depth of the flask. In the bottom of each flask is a drain opening with drain pipe and stop valve, for draining out water and oil.

The outlet pipes from the starting air flasks join into a single pipe which leads to a header on the inboard side of the engine. This header extends fore and aft along the engine, with a branch to the spray valve on each cylinder. Each branch pipe is carried above the level of the opening in the spray valve before bending down to meet the valve. This prevents the possibility of fuel oil from the spray valve leaking into the spray air pipe where it might become ignited.

Fuel Oil System. Fuel oil is drawn from the large storage tanks by an independent motor driven pump and discharged to an elevated gravity tank. From the gravity tank it flows to the suction box of the fuel pump unit at the operating station. This suction box is always full, due to the head from the elevated tank. A stop valve is provided in the line for shutting off the oil when it is desired to open up the suction box. Each pump in the fuel oil measuring pump unit has its own discharge pipe which leads to the cylinder supplied by that pump. A check valve is placed in each line near the spray valve. Where the oil line joins the spray valve is a by-pass valve, which may be opened when pumping oil through the line to clear it of air, or which may be used for cutting out that cylinder.

Cooling Water Circulating System. This system comprises the air compressor and intercooler, main working cylinder jackets and heads, exhaust valve cages, exhaust header, main guides and piston. Sea water is used throughout. The cooling water is supplied by a motor driven centrifugal pump.

From the pump a 7-inch inlet pipe goes to the air compressor jacket on outboard side. Small branches run to the bottom of each intercooler and discharge from top of intercoolers to the third stage jacket. From the top of the third stage jacket a 6-inch discharge line runs the length of the engine on the outboard side, with a branch connecting to the bottom of each working cylinder jacket. The water rises in the jackets, passes through the cored openings into the cylinder head jacket space, through the exhaust valve cage jacket space, out through a 2½-inch pipe from each exhaust valve cage to the exhaust header jacket, and thence overboard.

At a point near the outlet from each exhaust valve cage a thermometer is placed in the line so that the temperature of the cooling water from each individual cylinder may be noted. Connected to each outlet from the exhaust valve cage is a small test pipe which is led to a funnel on the inboard side of "A" frame 8, in order that the attendants may observe the flow of water from each separate jacket.

At a point near where the main inlet pipe joins the air compressor jacket a 3-inch line branches and runs the length of the engine on the outboard side. Opposite each working cylinder a branch from this line joins the piston cooling inlet pipe and the water passes up through a telescopic tube to the piston. The return from the piston is through a twin telescopic tube and out through a pipe to the piston cooling return water header. Forming a part of the lower section of each pair of telescopic tubes is a large air chamber which removes pulsations caused by the pumping action of the telescopic tubes. At the lower end of the reciprocating part of each tube are two leather cup washers, forming a piston and preventing leakage. The tube and air chamber assembly is supported on a strut between the "A" frames and at the upper end is fastened to the underside of the cylinder base with a gasket joint, thus preventing water leakage into the crank pit. Any water that may leak past the cup washers will discharge into the cylinder base and be conducted away through drains connected to the compartment un-

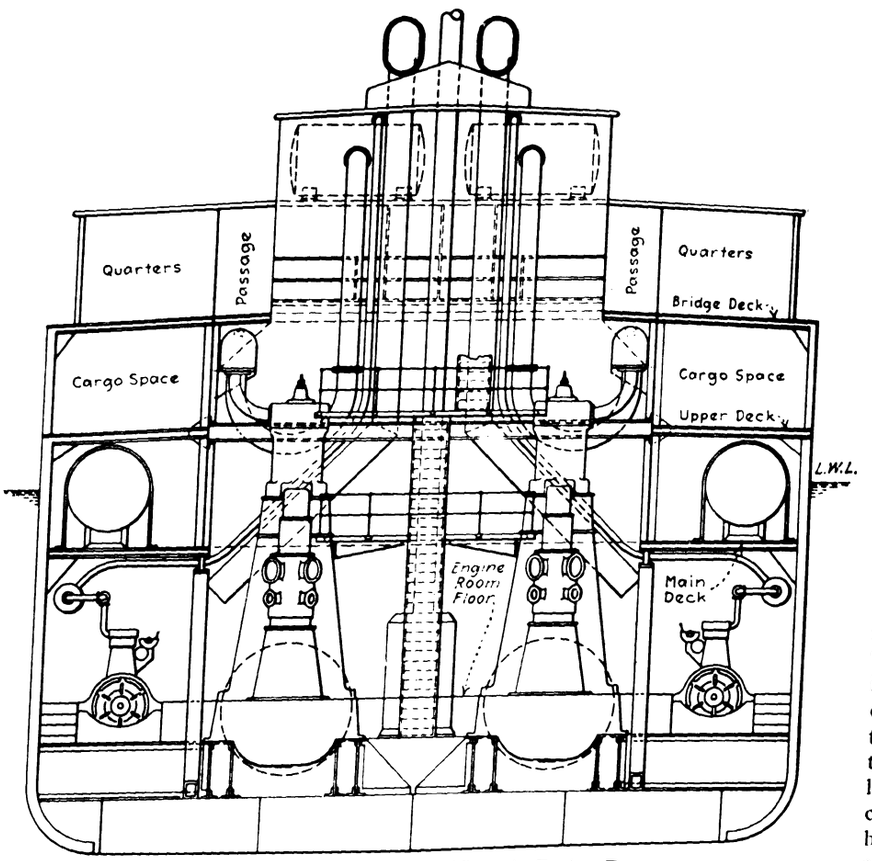

Fig. 23.—Cross Section Through Engine Room

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der each power cylinder. At the point where the telescopic tubes pass through the cylinder base a closely fitting spash hood is proided that will prevent any drops of water being thrown up onto the cylinder wall or piston rod.

The piston cooling water return header runs the length of the engine on the outboard side. At the forward end of the engine it discharges into the engine room bilge. Discharge from each piston into the header is through a funnel. This enables the attendants to watch the flow from each piston and test the temperature by feel.

A 2-inch branch from the main cooling water inlet passes across the front of the engine and connects to the crosshead guide water inlet header which runs fore and aft on the inboard side of the engine. A branch to each guide conveys water into the cooling space, whence it rises to the top of the guides and flows out into the outlet header. This outlet header runs forward and crosses over to join the main cooling water outlet near the point where it leaves the third stage compressor jacket.

Lubricating Oil System. Forced oil feed is used for lubricating all of the principal bearings. A motor driven, independent pump draws the oil from a sump tank below the engine room floor and discharges it at 15 pounds pressure into a fore and aft 3-inch header on the outboard side of the engine at the level of the main bearing. Opposite each main bearing a branch pipe passes through the leg of the "A" frame and connects to a passage through the main bearing cap. From the bearing the oil passes into the axial hole in the crankshaft through radial holes in the shaft which register with a circumferential groove in the bearing. It passes from the axial hole in the shaft through a hole in the crank web into an axial hole in the crankpin. From this axial hole it is conveyed through radial holes to a circumferential groove in the crankpin bearing. An axial hole in the connecting rod allows the oil to flow up through the rod to the crosshead pin bearing and crosshead guide. From there the oil falls into the pit formed by the closed engine bed, each compartment of which is fitted with a drain hole, and drains into a 6-inch header and thence to the sump tank.

From the forward end of the oil inlet header a small branch supplies oil to the compressor bearings. A branch from the aft end supplies oil to the thrust bearing and steady bearings.

For reclaiming oil that has become contaminated by continuous use, a Richardson oil filter is provided. In this filter the oil is heated and the water settled out; then it is forced through muslin filters that remove any foreign matter held in suspension. The filter is arranged so that a part or all of the oil may be cleaned. Filtration may be carried on while the engine is in operation or while it is stopped.

Lubricating oil is supplied to the power cylinders, compressor cylinders and auxiliary exhaust valves by Richardson force feed lubricators placed on the "A" frames on the inboard side of the engine in a position easily accessible from the engine room floor, and operated by gears from the camshaft. Each power cylinder has two separate feeds placed diametrically opposite and timed so that oil enters on the suction stroke.

The camshaft bearings are fitted with chain oilers running in an oil bath. Other minor bearings are fitted with oil cups.

Exhaust System. The exhaust is conducted from the exhaust valve outlets through pipes, curved to provide for expansion, into a horizontal manifold at the rear of the engine. This manifold is in two sections, one for each group of three cylinders, connected by a curved pipe.

Simplified Apparatus for Indicating Percentage of CO_2 in Flue Gases

DURING the war a new type of carbon dioxide indicator was developed which eliminated many of the complications of the usual type flue gas analyzer or recorder. The saving of coal, although important during the war, is even more essential now when the fuel shortage has curtailed production in many industries. The new indicator which is being manufactured by the Chadburn Ship Telegraph Company of America, Inc., Troy, N. Y., maintains a continuous record of the operation of a boiler in much the same manner as the water level is shown by the water glass.

As a matter of fact, the indicator is similar in construction to the water level tube, but is calibrated in percentages of CO_2. Its operation consists in drawing gases

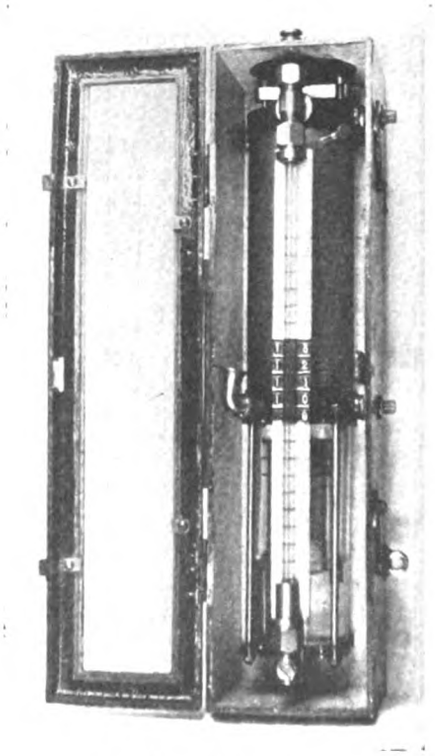

Fig. 1.—CO_2 Indicator

from the flue, which is under observation by means of a small steam-jet aspirator. The gas samples thus obtained are first drawn through a filter and into a chamber in which a porous pot containing a drying reagent is fitted. This chamber is connected through a small pipe to a vessel holding a quantity of water. Another pipe, one end of which is below the surface of the water, is led back to the porous pot. As the gas filters into the chamber, a certain volume penetrates the walls of the porous pot, where it is absorbed by the reagent, with the result that a partial vacuum is formed in the system, causing a colored liquid to be drawn into the indicating glass.

The indicator is fixed close to the boiler where it may be under the observation of the stoker at all times. If a low percentage of CO_2 is shown, the dampers of the boiler are opened. If the gage then registers still lower, it is apparent that too much air has been admitted, so the dampers are adjusted until the column indicates about 14 to 16 percent. Should anything happen to the fire the fact is instantly shown by the drop in the glass and the

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trouble can be immediately corrected, so that it is possible to maintain proper combustion at all times.

Where forced or induced draft is in use, the steam injector may be dispensed with, although actually but little steam is required to operate the jet, the average steam consumption being about one pound per hour. The only

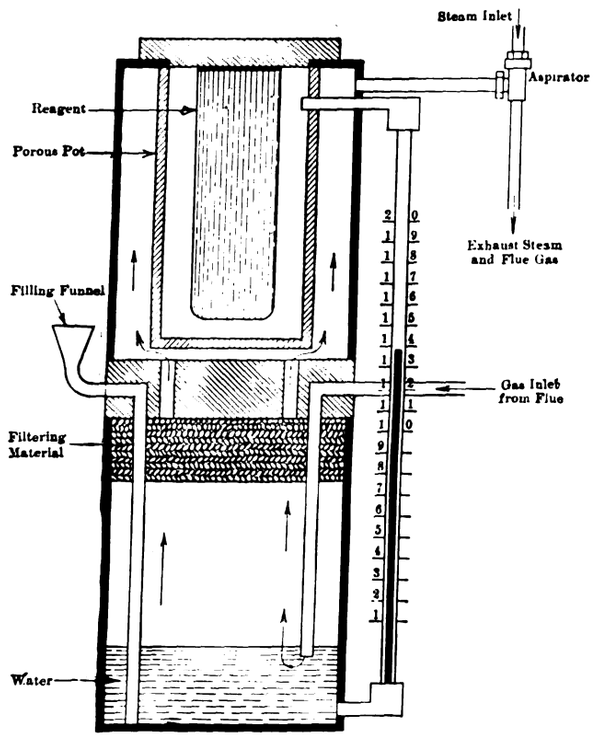


Fig. 2.—Diagrammatic Section Through Indicator

attention required in the maintenance of the instrument is the replacement of the drying reagent about once every forty-eight hours. As the chemicals are contained in a cartridge, which is readily placed in the proper position in the instrument, there is no danger of an inexperienced operator throwing out any adjustments.

In the operation of land and marine installations, where the equipment includes both automatic stokers and hand-fired boilers, the device has effected a minimum fuel saving of 10 percent. This saving in some cases has gone as high as 20 percent.

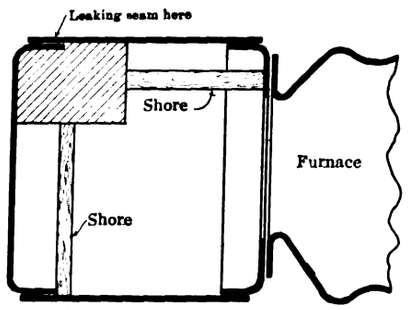
From the following table may be readily understood the possibilities of fuel conservation through the elimination of waste in the flue gases:

Novel Method of Stopping Leak in Combustion Chamber

BY W. S. ESPLIN

ON a twin screw vessel about four years old, which was equipped with five single ended boilers working under forced draft at a steam pressure of 205 pounds per square inch, boiler troubles were practically non-existant with the exception of some persistent leaks at the three ply joints of the combustion chambers. Time and time again several rivets were removed and renewed at the affected parts with more or less success in overcoming the difficulty. The chief difficulty encountered, however, when renewing these rivets was the inaccessibility of the position in the boiler and the narrow space existing between the combustion chambers, which made efficient holding up while riveting almost impossible and calking out of the question.

In one of the boilers, just prior to leaving Brooklyn, the center back end was re-riveted and calked at the affected part, but on the short run to Boston the trouble broke out afresh. Eventually this was entirely settled by having these seams treated by electric welding, but before this was done the defect was temporarily overcome by using a solution of Smooth-on applied as shown in sketch.



Sketch of Firebox, Showing Method of Holding Cement in Place

The box used was an ordinary well-made butter box measuring 15 inches by 12 inches by 12 inches. The lid and two sides having been removed, the box was put in position and scribed from the plates, so that when cut to the marks only a small amount of putty jointing was necessary to make it watertight. It was then shored in position (the boiler being empty) and filled with the Smooth-on mixture of a consistency similar to milk. About twelve hours was allowed for the solution to act, during which time one of the fireroom hands occasionally stirred the liquid to prevent undue settling.

THEORETICAL PERCENTAGE OF FUEL WASTED IN EXIT GASES AT VARIOUS TEMPERATURES

Temperature of Exit Gases in Degrees F.	Percentage of CO_2 in Exit Gases											
	4%	5%	6%	7%	8%	9%	10%	11%	12%	13%	14%	15%
100	8.1	6.5	5.4	4.7	4.1	3.7	3.3	3.0	2.8	2.6	2.4	2.3
200	16.2	13.1	10.9	9.4	8.3	7.4	6.7	6.1	5.7	5.3	4.9	4.6
300	24.3	19.6	16.4	14.2	12.5	11.2	10.1	9.2	8.5	7.9	7.4	6.9
400	32.4	26.2	21.8	18.9	16.4	14.9	13.4	12.3	11.4	10.6	9.8	9.2
500	40.5	32.7	27.3	23.6	20.8	18.6	16.8	15.4	14.2	13.2	12.3	11.6
600	48.6	39.3	32.8	28.3	24.9	22.3	20.2	18.5	17.1	15.9	14.8	13.9
700	56.7	45.8	38.2	33.1	29.1	26.0	23.5	21.6	19.9	18.5	17.2	16.2
800	64.8	52.4	43.7	37.8	33.2	29.7	26.9	24.7	22.8	21.2	19.7	18.5

In many boiler plants the percentage of CO_2 in the waste gases is as low as 6 percent. For example, where the record is at this figure with a gas exhaust temperature of 500 degrees F., a saving of 13 percent in the fuel consumption may be effected if the CO_2 is increased to 12 percent.

Before closing up the boiler finally an examination of the rivet heads and seam of the defective joint inside the boiler showed evidence of a faint trace of the liquid oozing through; the boiler was then closed, filled and put into commission in due course. The result was entirely satisfactory, and no further trouble was experienced.

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INTERNATIONAL
Marine Engineering
Published Monthly by
SIMMONS-BOARDMAN PUBLISHING COMPANY
6 East 39th Street and Woolworth Building, New York, N. Y.

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MARINE ENGINEERING is a member of the Associated Business Papers, Inc., (A. B. P.), National Association of Periodical Publishers, Inc., New York Business Publishers Association and the Audit Bureau of Circulations (A. B. C.).

The Leviathan

IT is to be regretted that only one concern, the United States Mail Steamship Company, submitted a bid for the *Leviathan,* and also that the amount offered for this magnificent vessel was only $3,000,000, with the conditions that the United States lend the steamship company $6,000,000 to repair the vessel and provide a berthing pier while the repairs were being done.

While it would cost in the neighborhood of $25,000,000 to reproduce the *Leviathan,* it is not probable that any company, either here or abroad, would attempt to build a vessel of this size under present conditions. It has been found very difficult to operate these large vessels on a paying basis, and, according to one of our English contemporaries, the experience which the Cunard Company has had with the *Imperator* has been by no means a particularly happy one.

The British, however, have not wasted any time in reconditioning their large vessels, and in the cases of the *Olympic* and *Aquitania* they have shown their progressive spirit by installing, at a prodigious cost, oil burning equipment in place of the coal furnaces. The return of the *Olympic* to the North Atlantic service was made the occasion for a special excursion, which was enjoyed by many notable people. Mr. Harold Sanderson, chairman of the Oceanic Steam Navigation Company, delivered a speech at a banquet held aboard the boat in which he referred to the *Olympic* as "the one ewe lamb" of their fleet. He dwelt at length on the cost of producing these great ships at the present time and held out no hope whatever that the Oceanic Steamship Company would build another *Olympic* for a long time to come.

At a recent luncheon, Admiral Benson stated that he was inclined to believe that it would be a good policy for the Government to accept the offer of the United States Mail Steamship Company. However, the Shipping Board probably will not render a decision on this bid until President Wilson has appointed a few at least of the seven members that constitute that Board under the provisions of the Merchant Marine Act. Considering the facts that it will cost between $8,000,000 and $10,000,000 to recondition the *Leviathan,* that the vessel is deteriorating perhaps more rapidly at her berth on the North river, where the water is known to be bad, than she would be in active service, that it is costing the Government a considerable sum each day that she remains in her present state, and that it is desirable to get her on an established run while the passenger traffic is good, it would appear that Admiral Benson is placed in a position that requires his most unbiased judgment.

The fact that the United States Mail Steamship Company was the only concern that had the enterprise to bid on this ship is not encouraging, but it is clear that the vessel cannot be allowed to remain idle. "We would fain suggest that the *Leviathan* is proving a white elephant to the United States," says an English paper. On this side of the Atlantic the most of us would fain see the *Leviathan* doing her bit toward establishing our merchant marine, even if it is necessary to dispose of her at what seems to be a low figure.

Forced Lubrication for Reciprocating Engines

WHILE so much time and money are being spent in designing and perfecting new types of marine machinery, would it not be a good idea to make every effort to perfect still further the machinery we now have installed and bring it up to a standard of reliability comparable with our newer installations? Some years ago it was thought that the reciprocating engine had been developed to the highest possible point of efficiency. To improve the economy of future installations it was thought necessary to turn either to turbines with reduction gears or to electric drive. But in spite of this we continued to build vessels with reciprocating engines, and there is no reason why they should not be equipped with any improvements that have been developed in the meantime. Moreover, those already in service, when their condition warrants it, should be brought up to the highest point of efficiency in order that the return on the investment may be as large as possible.

One direction in which a distinct improvement can be made is in the adoption of forced lubrication, as outlined elsewhere in this issue. While the exact cost of installing a forced lubrication system cannot be given, as it will vary with each type of vessel, it is believed that the improvement would pay for itself in a comparatively short time when the saving in oil, repair bills and delays caused by renewal of bearings is taken into consideration. If we are to expect the same reliability from our vessels equipped with reciprocating engines that we expect from our vessels equipped with geared turbines, we should install as satisfactory a lubricating system in them as we have today in our geared turbine installations. The same re-

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liability and small bills for repairs can then be expected, and no doubt obtained, by the installation of a satisfactory forced lubrication system with the reciprocating engines.

The Seamen's Act

THE penalty for desertion as outlined in the Seamen's Act provides that a sailor shall forfeit all or part of the clothes and effects that he leaves on board and all or any part of the wages that he has earned. This is not sufficient to prevent many sailors from abandoning their vessels in foreign ports, especially as they may demand half of the wages that are due them upon arrival. It certainly would not help the morale of a crew to deprive them of their shore leave or spending money, and to do so would work an injustice on the innocent, but it is evident that some means should be taken to prevent men who have no respect for a contract from leaving their vessels without cause in a foreign port. Is it not a fact, however, that this one weakness has prejudiced a great many of us against an act that is beneficial rather than detrimental to the development of our merchant marine?

Although much criticism has been expressed in regard to the privileges allowed American seamen under the Act of March 4, 1915, it is a fact that we cannot hope to induce American citizens to follow the sea unless we provide decent quarters and living conditions for them. Our most successful industries on shore pay particular attention to making their plants attractive, in spite of the fact that the number of men required to operate a manufacturing plant is far in excess of the number of sailors required to operate a ship. The provision that the quarters shall be so designed that each man will have at least 120 cubic feet of air space and 16 square feet of floor space is anything but excessive. Some of our cities have laws requiring at least 400 cubic feet of air space per man in their cheap lodging houses. The Norwegians have a law which provides that not more than four men shall be quartered in one room aboard ship, and it has been found that the men prefer this arrangement to the open forecastle. Such restrictions as that there shall be a separate berth for each seaman, that not more than one berth shall be placed above another, that the quarters shall be properly lighted, drained, heated, ventilated and protected as far as possible from the sea and from the gases from the bilge ought to be a matter of course and common sense, as is also the provision that ocean-going vessels which carry a crew of twelve or more men shall have a space set apart as a hospital, that there shall be at least one light, clean and properly ventilated washing place with at least one washing outfit for every two men on watch, and that there shall be a separate washing place for the engine and fireroom crew.

The above is the substance of the requirements that are necessary for the quarters. The size of the crew is specified as such that will allow a division of the sailors into at least two watches and the engine and fireroom force into three. The wages and subsistence items of the crew of a steamer are but a small percentage of the operating costs, and the wages of the few additional men required by this act (generally three or four) on American vessels does not constitute an item that would determine the successful operation of any ship. In fact, the higher wages of American seamen, which has nothing to do with the Seamen's Act, does not prevent the successful competition of American with foreign vessels. The Shipping Board has pointed out that the expenses of the crew of a steamer never constitutes more than 12 percent of the operating costs.

Passenger Vessels

TOO much emphasis cannot be placed upon the fact that our merchant marine is badly handicapped by a lack of passenger, fast freight and mail steamers. Our ships were constructed to supply the needs of a great emergency and, consequently, the bulk of these vessels are freighters. Every trade route that is not supplemented with a direct American passenger service must do business through foreign channels which will, of course, favor their own enterprises in so far as it is possible for them to do so.

If we are to secure our share of the trade of the great continents of Africa, South America and Asia, it is essential that our invoices, bills of lading, mail, and business men shall have direct intercourse with these countries through up-to-date and modern American passenger vessels, because it is only through such service that reasonably prompt deliveries can be assured at both ends and that the present serious obstacles to trade development can be removed. In the case of Africa, it is now necessary for passengers and mail to go by the way of England, from which country Africa enjoys excellent fast liner service. This means that bills of lading and invoices often arrive fifteen or twenty days after the goods they should accompany, with the result that deliveries are delayed and excess charges assessed.

Many lines are needed to provide regular and frequent service to the east and west coast of South America. It is an open secret that the people of South America are beginning to wonder if the United States intends to let its merchant marine drift back to the pre-war status. The superiority of the steamship service between Europe and South America over that between the United States and that country is very marked, and we are jeopardizing a splendid opportunity to establish closer and more cordial relations with the business men of South America by delaying the construction of suitable liners to cover properly the necessary routes. If the right kind of liner service is provided to back up the freighters that are now built, the trade between the United States and South America will quickly assume and maintain proportions and permanency that will insure our greatly expanded industries a market for their surplus production. The construction of our merchant marine was largely an act of patriotism; its maintenance and development should prove a profitable investment and is a necessity if our industries are to be kept at capacity production.

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LETTERS TO THE EDITOR

Opinions Wanted Regarding Fiber Packing for Condensers

I would appreciate any expressions of opinion I could obtain in regard to experience anyone has had with fiber packing for condensers for marine purposes, and if, in their opinion, fiber packing can be applied in stuffing boxes where the thread is cut to the bottom of the packing box.

Also, what is the best solution to use with corset lacing, Albany grease or linseed oil?

Harriman, Pa. W. T. WILSON, Works Manager, Merchant Shipbuilding Corporation.

Gravity Type Filters in Geared Turbine Lubricating Systems

In the June, 1920, issue of MARINE ENGINEERING I have read with interest an article by Messrs. Schmeltzer and Fernald on the subject of "Lubricating System for Geared Turbines."

I wish to direct attention to a gross and probably inadvertent misstatement which is made on page 510 in the paragraph entitled "Filters and Separators." In this paragraph mention is made of the fact that the centrifugal type of purifier is preferable because in the gravity filter the filtering elements, when placed in the gravity tank, will not function properly unless a sufficient head of oil can be obtained. Furthermore, due to the lack of this head, the oil will follow the line of least resistance and overflow without being filtered.

The Richardson-Phenix Company, Milwaukee, Wis., has furnished between 700 and 800 gravity type of filters for vessels, and of this number approximately 300 were used in connection with geared turbine lubricating systems.

The principle of the R-P type of filter is such that the oil is caused to pass through the filtering medium, which is cloth in a vertical position, at a very low head, ranging from 2 inches to 12 inches. This head is obtained in the filter tank itself and is not dependent in any way whatsoever upon the outside piping or the balance of the system. Furthermore, a high head is quite undesirable because of the fact that forcing oil through the filtering medium under a greater pressure than that obtained from an average of, say, 4 inches will cause the very fine particles of dirt and foreign matter to be forced through the filtering medium along with the oil, thus lowering the efficiency of the filter.

Messrs. Schmeltzer and Fernald in their article entirely omit mentioning the difficulties which have been encountered with the mechanical or centrifugal type of oil filter. The multiplicity of parts moving at such a high rate of speed almost require an oiling system in themselves to keep the purifier in operation. Then, again, the problem of cleaning the gravity type of filter, which has no moving parts, as against cleaning the bowl of a centrifugal oil purifier is such a simple proposition that it is preferred by marine engineers, who demand something which will accomplish the desired results, that is, restore the oil to its original lubricating value with the least number of complications.

In justice to the experiences which the writer, as well as other engineers who have installed gravity oil filters, have had in this line, we believe that the information above should be given due publicity in your valued journal.

New York. EDWIN M. MAY, District Manager, The Richardson-Phenix Company.

United States Battleships of the Year 1914 and Later Classes*

The editorial in the May issue of MARINE ENGINEERING, entitled "Two Years of Electric Propulsion on the *New Mexico*," is of vital concern to everyone connected with large naval vessels and interested in the important question as to the most suitable type of propelling machinery.

It is, however, with some hesitation that I take up my pen and make replies to many of the statements, owing to the fact that the data given are copied from a report submitted by my good friend, Commander S. M. Robinson, fleet engineer of the Pacific Fleet, and comments are bound to seem somewhat presumptuous in view of the first hand information that was available to the author.

The remarks dealing with the maneuvering qualities of the *New Mexico* are of special interest, and my experience has shown that most turbine ships are also capable of turning completely round without gaining ground, either ahead or astern. The Cunard liners *Mauretania* and *Lusitania* have done this stunt regularly in New York Harbor, off the Quarantine Station.

I note that it is customary with this ship when maneuvering either in restricted or in dangerous waters to use only one turbo-generator and that this combination has shown the more satisfactory method of operation. It seems to me that this shows it is not necessary or desirable to use equivalent to full ahead power when backing, and justifies the arguments of the turbine builders who have always felt that 50 to 60 percent backing power was ample for all requirements, whereas the electric drive enthusiasts have repeatedly advocated the necessity or desirability of having "full power" astern.

The three battleships *New Mexico, Mississippi* and *Idaho* are sister ships in every sense as regards proportions of the vessels, but the designs of the propelling machinery are so different in each case that it is almost impossible to make comparisons of performance that can be considered fair or just.

Each ship is driven by four propeller wheels and has a designed sea speed of 21 knots, but the revolutions differ: (No. 40) *New Mexico*, 175 revolutions per minute; (No. 41) *Mississippi*, 240 revolutions per minute; (No. 42) *Idaho*, 240 revolutions per minute.

This feature alone gives the *New Mexico* a great advantage over her so-called sister ships, inasmuch as the slower revolutions make more efficient propellers.

In addition, the *New Mexico* is the only one that has carried out complete sets of speed and oil fuel consumption trials under the supervision of the Board of Inspection and Survey. This makes it possible to use the data so obtained on these tests and compute comparisons with the less fortunate vessels, so that comparative performances will always show up favorably in the vessel which was fully tested out by reliable trials. The *New Mexico* did, however, carry out two sets of trials, the first proving very unsatisfactory.

In view of the fact that the art of propelling vessels by direct driven and geared steam turbines has progressed

* *References:*
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to a remarkable extent during the last ten years, it is only right that the subject of the machinery for these vessels should be examined, not so much from the point of view of results in service, but to ascertain just why such machinery installations were built for the *Idaho* and *Mississippi*, which apparently compare so unfavorably with the *New Mexico*. This can best be done by referring to the bids which the various shipbuilders offered to the Navy Department in Washington on October 6, 1914. Four shipbuilding firms submitted proposals, but I shall only refer to those submitted by the successful contractors. Of these three ships, one was required to be built in a Navy Yard.

The New York Shipbuilding Corporation made three proposals, the lowest in price having Parsons geared turbines, while the bid accepted by the Navy Department has direct driven turbines costing $75,000 more than the former, and this firm was awarded a contract to build the *Idaho*.

The Newport News Shipbuilding and Dry Dock Company made three proposals, all of which had direct driven turbine machinery, and this firm built the *Mississippi*, having the Brown-Curtis type of direct drive turbine.

In 1915, battleships Nos. 43 and 44 (the *Tennessee* and *California*) were authorized to be built at Navy Yards, so no public bids were called for in these cases, and both of these ships are fitted with electric propelling machinery.

Battleships Nos. 45 to 48 were ordered in 1916 and bids were opened in Washington on October 25. Two of these ships are building at each of the following shipyards: New York Shipbuilding Corporation and Newport News Shipbuilding and Dry Dock Company. All have electric propelling machinery, which is being supplied by the Navy Department, the contractors for the vessels not being in any way responsible for satisfactory operation. Both of these firms submitted splendid propositions with geared turbines, but they were rejected.

The foregoing clearly shows that the shipbuilders fully realized the possibilities of mechanical reduction gears, and a geared turbine installation in the battleship *Idaho* would have made a reliable and accurate comparison with the *New Mexico*.

The various bids received for building destroyers also show that the shipbuilders had clearly recognized the great advantages of geared turbines.

Destroyers Nos. 57 to 62 were ordered in 1913, and the Bath Iron Works, Ltd., was awarded a contract for one vessel with two sets of Parsons geared turbines. This was the *Wadsworth*, No. 60. The other five have direct driven turbines and geared cruising units.

Destroyers Nos. 63 to 68 were ordered in 1914, and the Navy Department plans and specifications especially called for geared turbines. Various bids were received for vessels of this type, but all were finally contracted for with direct driven turbines.

Early in 1915 the destroyer *Wadsworth* completed her preliminary acceptance trials, breaking all known records of fuel consumption at every speed for vessels of this type, and it was only at this time that the Navy Department began to appreciate and realize the importance of geared turbine machinery.

Destroyers Nos. 69 to 74 were ordered in the fall of 1915, and in this case the Navy Department plans called for direct driven turbines, but only two were built to the Department plans, having 3-shaft turbines, the other four having twin sets of geared turbines. Of the four vessels having gears, only one has had any gearing trouble, No. 69, the *Caldwell*, the machinery for which was built by the General Electric Company, Schenectady, N. Y.

In October, 1916, destroyers Nos. 75 to 94 were ordered. All have twin screws driven by geared steam turbines.

Again, the great fleet of destroyers contracted for during the war, Nos. 95 to 347, have twin sets of geared turbines, and the general arrangement of the machinery in all these vessels closely resembles the original machinery installation of the pioneer geared turbine destroyer *Wadsworth*.

One of the great advantages claimed for electric drive was that this type of machinery would not be subjected to breakdowns, necessitating Navy Yard repairs. There are only two such vessels, the collier *Jupiter* and the battleship *New Mexico*, at sea, and both have developed mechanical defects. The *Jupiter* stripped blading during one of the first series of trials off the Pacific Coast. As stated in the report, the *New Mexico* also had what was undoubtedly a serious accident, for it necessitated installing a new rotor in one turbo-generator and a thorough overhaul of the armature. While both of these accidents may not have had anything to do with the system of propulsion in use, yet it does show that such machinery is not necessarily immune from accident.

Practically nothing is said about high speed condition of these three battleships, except that the *New Mexico* is rated between 21 and 22 knots. Her actual speed is a little over 21 knots, and all full speed runs have shown this vessel to be the slowest of the trio. In high speed runs the *Idaho* always maintains the lead, followed by the *Mississippi*, while trailing astern comes the *New Mexico*. In view of the fact that her motors can develop 37,000 shaft horsepower, this feature is not altogether reassuring, but differences of this sort can generally be explained satisfactorily by pointing to the boiler room equipments.

The statement which infers that the direct driven turbine destroyers having geared cruising units compare favorably in fuel consumption with all-geared turbine destroyers is difficult to understand, as an up-to-date all-geared turbine battleship with Parsons machinery will show great gains in fuel economy over the direct driven turbines and geared cruising units. To justify my remarks, I herewith give average representative figures of "oil fuel consumption in pounds per knot run" for some of the Parsons turbine driven destroyers:

TWIN SCREW DIRECT DRIVEN PARSONS TURBINES WITH ONE GEARED CRUISING UNIT

Knots	(No. 58) *Conyngham* (No. 59) *Porter* (No. 67) *Wilkes*	(No. 61) *Wainwright*
12	130	157
16	144	176
20	182	217
25	380	390
29.50	562	640

TWIN SCREW ALL GEARED PARSONS TURBINES

Knots	(No. 60) *Wadsworth*	Nos. 75 to 78 Nos. 113 to 118 Nos. 125 to 130
12	116.50	100 to 130
16	120.50	138 to 150
20	152.50	180 to 200
25	275	264 to 320
30	473	433 to 480
35	.....	623 to 686

The foregoing figures speak for themselves. They do not take into account that the displacement of the all-geared boats (except the *Wadsworth*) is much greater than the direct driven vessels. Again, at full power in excess of 35 knots, and at the cruising speed of 25 knots in the case of the all-geared ships, the fuel consumption varies between .875 pound to .95 pound of oil fuel per

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shaft horsepower for all purposes, and these results have been attained in a large number of these vessels.

With reference to the direct driven turbine battleships, it should not be overlooked or forgotten that the performance of these ships has been excellent. The *Florida* still holds the full speed record for any American battleship, namely, 22.08 knots for four hours, made during the official acceptance trials in 1912, while the record of the *Wyoming*, as regards freedom from accident and reliability of machinery, has never been approached by any other vessel of her class.

The only all-geared turbine installation in any American battleship has been fitted recently in the *North Dakota*, and this has been an unqualified success. The original machinery consisted of twin sets of direct driven Curtis turbines, now replaced by Parsons geared turbines, built in the New York Navy Yard, Brooklyn, N. Y.

To really appreciate the great strides "the all-geared turbine" has made during the last six years in warships, I strongly advise engineers and naval architects to read the following papers which were presented before The Institution of Naval Architects, London, at the recent annual meetings:

"H. M. S. *Hood*," by Sir Eustace D'Eyncourt, K. C. B., vice-president,

"Experience and Practice in Mechanical Reduction Gears in Warships," by Engineer-Commander H. B. Tostevin, D. S. O., R. N.

I cannot understand just why Mr. Robinson has attempted to make comparisons between the *New Mexico* and the so-called sister ships. The cruising arrangements of the two turbine driven ships are so radically different that comparisons which are to be of any value should be made according to the results obtained with each ship. The *Mississippi* can use the cruising turbines only up to 15 knots, about one-fourth maximum power, while the *Idaho* can cruise up to 17 knots, about two-fifths maximum power; therefore, it stands to reason that these vessels cannot be compared on equal terms with a third vessel.

I fully realize that the economy of the *New Mexico* machinery is bound to be very good, if the vessel is driven entirely by one turbo-generator, the other, with its auxiliaries, being shut down. This, however, cannot in any way be considered as the regular way in which the machinery is being operated, and when she is a unit in a division, doing drill and battle practice, it will be essential that the other generator and its auxiliaries are turning over idly. It is only on a long sea cruise that one turbo-generator can really be used to advantage, *and only in peace times*. There is absolutely no military advantage gained in operating capital warships under such conditions, and while this gives a very easy time for the engine room personnel, *yet it would never be done during a war in the open seas*.

In conclusion, I fully appreciate the difficulties before one who attempts to make comparisons between a modern electrical driven battleship with its slow turning propeller wheels and direct driven turbines having fast turning propellers, and I have little hesitation in saying that any such comparisons should be used with the utmost caution.

New York. ERNEST H. B. ANDERSON,
Parsons Marine Steam Turbine Company.

OIL FUEL PROVES ECONOMICAL.—The Norwegian American liner *Bergensfjord*, recently converted to an oil burner, made her initial voyage from Christiania to New York at a speed of about 17 knots as compared with her former record of 15 knots as a coal burner. About 1,250 tons of fuel oil were consumed on the voyage and twenty-five less firemen were required to operate the vessel.

NEW BOOKS

The New Merchant Marine

THE NEW MERCHANT MARINE. By Edward N. Hurley, formerly chairman of the United States Shipping Board. Size, 5½ by 8 inches. Pages, 296. Illustrations, 8. New York, 1920: The Century Company. Price, $3.

This book is primarily a report to the American people on the construction, operation and the necessity for the permanent development of our new merchant marine. By report, I do not mean a mass of statistics, but rather an interesting and easily followed narration of the stupendous work accomplished by the Shipping Board and the value of the merchant marine to the prosperity of our country and to the world.

Starting with a description of our merchant marine in the early days, in which the growth and subsequent disappearance of our ships from the seven seas are explained, Mr. Hurley shows how difficult it would have been in the ordinary course of events for our country to return to its heritage on the seas.

The organization, preparations and problems of the Shipping Board are then dealt with and the enormous work which was accomplished in the building and fabrication of our new merchant marine is visualized insofar as it is possible to do so with words.

Passing from the construction of the merchant marine to operation, a subject which to most of us is both fascinating and mysterious, Mr. Hurley explains in detail from his experience as the former head of the largest shipping organization in the world the problems that have to do with ship operation. After reading this book the most skeptical should be convinced that the higher wages and better treatment of our sailors are not an appreciable percentage of the operating costs. The greatest value of this book, however, lies in the clear explanation of the trade routes that should be developed, the necessity for passenger lines, particularly between this country and South America and Asia, and the necessity for American insurance for American ships and cargoes. If Mr. Hurley's work could be read by the majority of our countrymen, the future of our merchant marine would be assured.

Diesel Engine Design

REVIEWED BY C. H. PEABODY, DR. ENG.

DIESEL ENGINE DESIGN. By H. F. P. Purday, B. Sc. Size, 5½ by 8½ inches. Pages, 302. Illustrations, 271. New York, 1920: D. Van Nostrand Company. Price, $7.50.

The Diesel engine is only a quarter of a century old, but it is now thoroughly established and its characteristics and limitations are as well known as those of the steam engine. The author of this work has been a designer of Diesel engines for half that time and is familiar with the general principle and the details of construction; the latter are given with particularity, and on them the proper working of the engine depends more than for any other heat engine. The author is writing for designers and passes lightly over such matters as are familiar to designers. In places a somewhat more extensive presentation would be desirable for the general reader.

The book is limited to the standard type of the Diesel engine and leaves aside not only the hot bulb engine (sometimes called the semi-Diesel engine), but also engines which work on the Diesel cycle but with mechanical ignition of the fuel.

The essential Diesel principles are:

(1) Compression sufficient to produce the temperature

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requisite for spontaneous combustion of the fuel.

(2) Injection of fuel by a blast of compressed air.

(3) A maximum cycle pressure not greatly exceeding the compression pressure, i. e., absence of a pronounced explosive effect.

We may have in mind that the pressure requisite is 500 to 550 pounds for the four-stroke engine and may be 600 for the two-stroke engine. The temperature corresponding is about 1,200 degrees F. The air blast supplies one-twelfth of the air for combustion.

In the thermodynamic discussion the author assumes that the rate of fuel injection is so regulated that the pressure remains constant, and that the expansion curve has the exponent 1.35, which indicates the existence of after-burning. In practice the pressure is likely to rise during fuel injection. The excess of pressure above that by compression is controlled to avoid excessive temperatures and excessive after-burning. The author computes the efficiency of an ideal diagram with a flat top as 0.57 and states that a splendid actual efficiency is 0.35, so that the ratio is 0.82, from which he draws the conclusion that the margin for improvement is very narrow. Now the thermodynamic theory of the internal combustion engine is difficult and unsatisfactory and the ratio just stated may be accepted with considerable reserve. It has a substantial advantage in that it emphasizes the fact that the Diesel engine has ar ved at its complete development and that improvements, if they can be found, will be in minor details. The Diesel engine had the advantage at its inception that engineers were already equipped with sufficient knowledge and shops with requisite machinery so that perfection was approached rapidly, whereas the steam engine required a century to build up the metallurgical and engineering industries needed for its perfection.

The author gives as a typical heat balance: Work, 42 percent; cooling water, 34 percent, and exhaust, 24 percent. This is a good showing; it is immaterial whether rejected heat goes to cooling water or to exhaust. Following a fashion that has somewhat gone by, the author discusses the entropy chart of the cycle. Some engineers are of the opinion that entropy, which was invented for the discussion of the steam engine, may well be limited to that engine and that other diagrams must be treated with great discretion, if errors are to be avoided.

As an introduction to design, the author gives the principles of similitude and computes special tables for the use of that method. The principles are similar to those for steam engines and he finds that similar engines have the power proportional to the square of diameter while the weight is proportional to the cube, as is the case for steam engines. As is well known, this militates against the unlimited growth of engines; the case is harder for internal combustion engines because steam boilers are not subject to this law, and for various reasons both mean effective pressure and piston speed are reduced for large sizes of internal combustion engines. The steam engine has escaped from this restriction by changing into steam turbines, but the Diesel engine, despite the efforts of competent engineers for nearly a quarter of a century, remains a small power engine. Experimental engines developing a thousand horsepower in one cylinder have been constructed, but at sea, where the Diesel engine finds its most promising field, three hundred horsepower per cylinder is near the limit in practice. However, with six or eight cylinders to an engine, twin screw installations can take care of the bulk of freight and a good deal of passenger service.

With the high pressures and temperatures of the Diesel engine, lubrication is of prime importance. Two conditions arise according as the engine has a trunk piston or a crosshead; the latter type demands forced lubrication for all but small engines, and the largest powers require the oil to be cooled.

The crankshaft for engines with three or more cylinders may have a natural balance, but the eccentricity of individual cranks in any case will bring binding moments at the bearings, and even slight bending increases friction and wear of the bearings. Where possible, it is desirable to counterweight each crank, the only difficulty being to find space.

The author goes at some length into computation of stresses, in the pistons, crossheads (when used), connecting rods and crankshafts, including inertia forces; he is content to use either approximations or graphical methods, although exact results may be easily had if acceleration tables are provided similar to those used for steam engines. His treatment of torsional oscillation of the crankshaft and methods of avoiding that evil are excellent.

Flywheels are very important even for engines with multiple cylinders, especially for four-stroke cycles. This feature is the more important as the governor controls the fuel supply and there is considerable lag due to the fuel already beyond the governor's control. There are various modifications of control by the governor; perhaps the simplest is the provision of a plunger under control of the governor which holds the suction valve of the fuel pump off its seat for a period that decreases with the demand for power. The effect is the same as the use of a by-pass to reduce the delivery of a constant stroke pump.

The lubrication of the main bearings gives less trouble than might be expected considering the high initial pressure. The author calls attention to the fact that the pressure is momentary and time is required to break down an oil film. He says that for a peripheral speed of 550 feet per second ring lubrication is sufficient; when the speed is 750 feet per second forced lubrication is called for, and at higher speeds the oil must be cooled. The lubrication of the piston requires not so much a large supply of oil as even distribution, for which reason oil is supplied at six or eight circumferential points.

Many of the items rehearsed are interesting, as they show differences from steam engine practice and the requirement of judiciously arranged details. Unexpected points come up; in the author's opinion the best way of providing for small parts not readily water cooled is to connect them metallically with larger masses which are water cooled. This arises in discussing webbing of cylinder heads. Again he calls attention to the tapering of trunk pistons at the top where the temperature is high and expansion is large. His figures of connecting rods show forms substantially like those for marine steam engines at the big end; the little ends are commonly worked out of solid blocks on the rod on account of lack of space. Another curious feature is cross-bending of the connecting rod on account of friction at the crank pin when lubrication is accidentally insufficient.

Various arrangements of fuel injection valves are shown together with provision for control by the governor. Some are very ingenious. The governor must have considerable power, as it acts directly or indirectly on the valves. Like the valves for all internal combustion engines, these are operated by cam and must be loaded with springs that are capable of dealing with inertia forces of valves and levers as well as friction and pressure. It is rather curious that the author in his discussion of accelerating forces for valves uses the Newtonian notation instead of the usual forms for the differential coefficients.

We are all familiar with the noise made by internal

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combustion engines which are insufficiently muffled at the exhaust. It will be novel to some that marine Diesel engines have silencing devices on the air suction. Land engines are very thoroughly muffled—sometimes with iron mufflers six times as large as a cylinder, sometimes having large concrete chambers twenty to thirty times the size of a cylinder. A moderate-sized muffler may answer, if the exhaust enters it through a trumpet-shaped diffuser.

Since the use of main blast for pulverizing the oil requires a considerable volume of air at 900 to 1,000 pounds per square inch, the arrangement of the air compressor and its system must be thoroughly worked out. Two or even three stage compressors are used with various drives—sometimes from the crankshaft, sometimes from a crosshead through levers, and sometimes by separate motors. The conditions and methods of design are not very different from compressed air work in general.

The author finishes with a chapter on valve gears which have the characteristics of cam gears, as used for all internal combustion engines. Marine Diesel engine valve gears have some complication in order to provide for maneuvering and reversing the engine. This may be realized from the author's summary of requirements for such gears:

(1) When the engine is standing the blast air should be cut off.
(2) The blast air should be turned on immediately when the engine starts.
(3) When the engine is standing the starting air should be turned off.
(4) The fuel pump suction valves should be held off their seats until the fuel valves are in running position.
(5) The fuel valve should be a handle with wide range of movement between no oil and full oil.
(6) A wheel or lever is provided with suitable mechanism for putting the starting valves into action, subsequently for putting them out of action when the engine gets under way.
(7) Some type of interlocking gear is usually fitted to prevent false moves.

Marine Boiler Management and Construction

REVIEWED BY C. H. PEABODY, DR. ENG.

MARINE BOILER MANAGEMENT AND CONSTRUCTION. Fifth edition. By C. E. Stromeyer, M. I. C. E. Size, 5½ by 8¼ inches. Pages, 437. Illustrations, 466. New York, 1919: Longmans, Green & Company. Price, $5.

This is the fifth edition of a well-known work on boilers as used at sea; the first edition was published in 1893 and the book might be considered a classic were it not so very much alive in this present edition.

The most notable feature in which it differs from the fourth edition is the final chapter, giving the findings of the British Marine Engineering and Design Committee, in anticipation of the adoption of their report by the various authorities that appointed the committee. It is needless to say that the rules and methods recommended by the committee are eminently practical and useful; this chapter alone makes the book a distinct advance. The book also gives the most recent Lloyd's rules and British Board of Trade rules for boilers.

The book opens with directions for boiler management, especially for Scotch boilers, and has chapters on properties of steam, on corrosion, on fuels and combustion and on heat transmission. These are proper for any book on boilers, whether for land or sea service. It is to be noted that the tables for steam are taken from Regnault and Rankine; but for boilers almost any steam tables are sufficient.

The discussion of strength of boiler materials is very much to the purpose because of the peculiarities of service; the chapter on mechanics may perhaps be justified on the same basis. If there is any criticism of the chapters on construction and design, it may be directed to an exclusive consideration of the Scotch boiler, which is indeed the standard for merchant practice, but is now threatened by the watertube boiler. In the chapter on steam pipes the most recent methods of construction by electric and acetylene welding are considered, as well as the older standard methods.

An Exporter's Reference Guide

EXPORTER'S GAZETTEER OF FOREIGN MARKETS, 1920-1921. Compiled and edited by Lloyd R. Morris, research editor, The American Exporter. Size, 5¾ by 8¼ inches. Pages, 808. Illustrations, 36 maps and 7 charts. New York, 1920: Johnston Export Publishing Company. Price, $10.

Published for the use of manufacturers, exporters, bankers, shipping and allied interests, this book gives a condensed survey of the world's markets and industries. A unique feature of the arrangement of the work is that all the commercial and industrial statistics and weights and measures have been converted into dollars and into American measurements, so that the business executive can get his facts immediately without going through the process of converting from foreign currencies or measures. It is believed that this is the first time that a book of this nature has been compiled in that manner. Furthermore, it is the first time that all these details of foreign conditions have been available in one volume, as heretofore it has been necessary to consult local publications and various governmental reports in order to cover the same ground.

The countries of the world have been grouped in alphabetical order by continents and other major geographical divisions so that adjoining markets are found together.

Under each country will be found detailed information upon area and population, commerce, production and industry, railroads, telegraphs and telephones, money, weights, measures, commercial language, local advertising media, principal shipping routes, customs tariffs, consular regulations and consular representatives, cable rates, mail time, postal rates, and regulations respecting parcel post, money orders and reply coupons. The section under each country dealing with commerce contains tables showing the value of the total foreign trade for a series of years, the value of imports and exports by commodities and countries, and the value of its imports from and exports to the United States for ten or more years.

Under production and industry there will be found with respect to each country a detailed survey of its various industries, including agriculture, livestock, forest and mineral resources, fisheries and manufactures, and in the majority of cases there has been included a table showing the number of each kind of manufacturing enterprise, together with the number of persons employed, the capitalization, the value of annual output and the consumption of raw material.

Tables are also given showing the world's production and consumption of the principal grains, minerals and other primary commodities, also the world's equipment of shipping, railroads, telegraphs and automobiles.

Comparative tables showing the relative growth of the export and import trade of the United States, Great Britain, France and Germany are also given.

Separate sections of the book are devoted to the new states of Czecho-Slovakia, Jugo-Slavia, Poland, Finland, Latvia, Lithuania, Esthonia, Ukrania, and Austria and Hungary as reconstructed.

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Questions and Answers for Marine Engineers

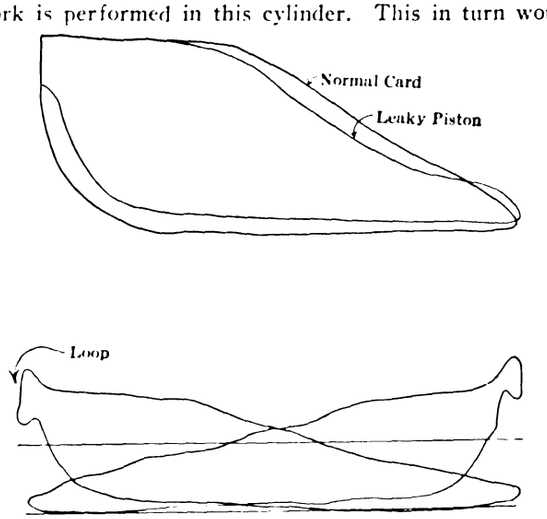
Inquiries of General Interest Regarding Marine Engineering and Shipbuilding Will Be Answered in this Department

This department is maintained for the service of practical marine engineers, draftsmen and shipbuilders. All inquiries should bear the name and address of the writer. Anonymous communications will not be considered. The identity of the writer, however, will not be disclosed unless the editor is given permission to do so.

Effect of Leaky Piston on Indicator Card

Q. (1048).—Will you please give information in regard to steam indicator cards. How can one tell from the card if there is leakage in the cylinder? For example, if a card from a high pressure cylinder of a triple expansion engine seems to have low indicated horsepower and excessive back pressure, how do you figure just what the back pressure ought to be? J. L. T.

A. (1048).—Should the piston rings or piston leak, a normal diagram would approach that sketched in dotted; that is, the expansion line will drop off, or, in other words, steam blows from the high pressure to the low pressure side of the piston. During the return or up stroke, steam will blow through from the bottom end of the cylinder, with the result that the exhaust line is raised and less work is performed in this cylinder. This in turn would



Indicator Cards Showing Effects of Leaky Pistons

mean a higher admission pressure in the next cylinder of a multiple expansion engine and more work performed there. During compression the compression line should show a level place or even a drop due to steam in compression on the upper side of the piston blowing through to the under side, which is indicated in the curious loop in our diagram.

One way of obtaining a rough equalization of power is to alter cut-offs so that the engine runs smoothly with little vibration. If, when indicated horsepower of the cards is worked out, the distribution of power is not good, an estimate of the amount to change the receiver pressure by changing cut-off can be approximated from the previous power and receiver pressures. In one example of a compound engine, which took steam at 85 pounds pressure absolute and exhausted it at 3 pounds absolute, when the low pressure cut-off was adjusted so that the high pressure receiver pressure rose from 11 to 13 pounds, the indicated horsepower was decreased about 4 percent in the high pressure cylinder and increased a corresponding amount in the low pressure. This would indicate that very approximately 1 percent change in "pressure range" (difference between admission and exhaust pressure) would produce a corresponding variation in horsepower.

Raked Smokestacks

Q. (1046).—Will you please tell me why most of the smokestacks on many passenger vessels are set at an angle? T. M.

A. (1046).—This is probably due to the desire to make the smokestack and vessel look snappy. Most sailing vessels have their masts raked, and when steamers were first built it was simply natural to give their masts and stacks a rake. A stack with a marked rake and with wind ahead should slightly increase the draft. However, our new destroyers have stacks which are nearly perpendicular.

Chain for Anchor-Tripping Gear

Q. (1049).—Kindly advise me why it is necessary to use three different size links in an anchor lashing which is secured about as shown

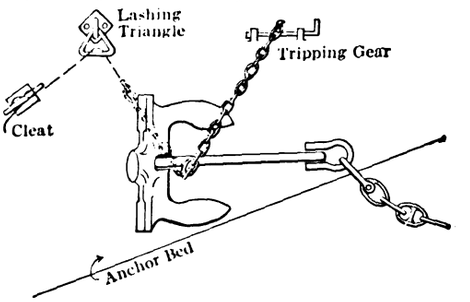


Fig. 1

in the sketch (Fig. 1). To me it looks as though the pull was equally distributed through the chain and one size link should be used. R. B. R.

A. (1049).—I have never seen the tripping gear fitted as your sketch indicates, and likewise cannot understand why three different sizes of links should be fitted in a

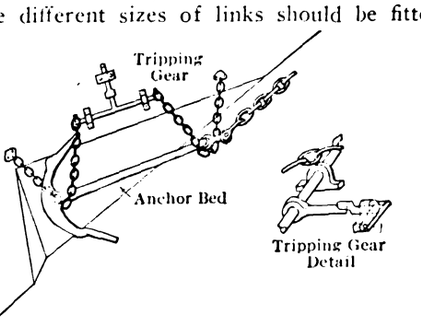


Fig. 2

length of chain which takes stress equally throughout. The only possible partial explanation would be that a shorter link is convenient where the chain is belayed on a cleat.

Fig. 2 illustrates a common method of fitting tripping

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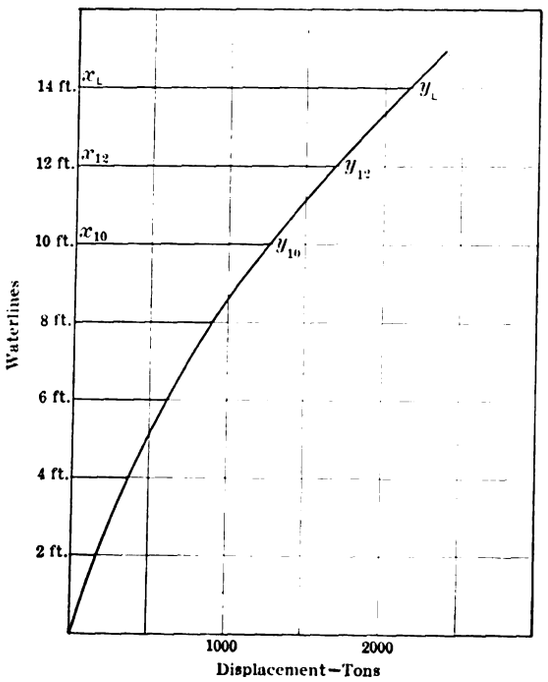
gear to an admiralty (or navy) type stock anchor. Besides the tripping chains (approximately one-half inch for a 1,800-pound anchor) indicated in the sketch, there are several lengths of about 5/16-inch close link chain used to lash the anchor in place while stowed, but these are entirely separate from the tripping chains.

Relation Between Displacement and Waterline Area

Q. (1045).—What relation has the area of the water-planes to the distance from *X* to *Y* on the displacement scale? C. F. T.

A. (1045).—The displacement curve shows the displacement up to the waterline which we are concerned with. The displacement can also be obtained, if we know



Displacement Curve

the areas of the waterlines, by considering the vessel to be made up of a series of solids or slices obtained by cutting the vessel with the waterline planes. The volumes of these solids may be added to find the displacement of the vessel up to any required waterline (a displacement

The volume of the solid whose section is represented by A B C D is taken as the volume of a cylinder of the same height and of sectional area equal to the mean of water lines AB and CD

sheet worked out by the trapezoidal rule would have the displacement computed in this manner). If the distance between successive waterline planes be multiplied by the average of their areas, the volume of the solid or slice will be found quite closely.

Thus, in the case represented by our figure,

$$\frac{A_L + A_{12}}{2}(x_L - x_{12}) = (y_L x_L - y_{12} x_{12}),$$

where

A_L = area of the load waterline.
A_{12} = area of 12-foot waterline.
$x_L x_{12}$ = 2 feet.

The above equation is true for all practical purposes, if the waterline planes are fairly close together. Where the curvature of a vessel's transverse stations is considerable, as at the bilge of a cargo ship, the greatest variation will occur. The table given below illustrates the fact that this equation holds, for column (3) represents the second member of our equation and column (6) the first member:

Waterline, Feet	Displacement, in Tons (From Displacement Curve)	Difference in Displacement Between Successive Waterlines	Average Area of Waterline, Square Feet	Average Area of Waterlines, Square Feet	Displacement Between Successive Waterlines, Tons
2	149	.....	2,610	.....	...
4	347	198	4,320	3,465	198
6	626.5	279.5	5,460	4,890	279
8	962	335.5	6,290	5,875	336
10	1,341	379	6,960	6,625	378
12	1,753	412	7,450	7,205	412
14	2,189	436	7,800	7,625	436

Approximate Freeboard

Q. (1053).—Kindly describe a quick and simple method of figuring the freeboard of a vessel. C. H. B.

A. (1053).—The freeboard of a vessel depends upon a good many factors, among which are the following: Type of vessel, strength of hull and houses, sheer of deck, trade of vessel, time of year. You realize, of course, that freeboard markings are placed on vessels by the American Bureau or Lloyds Register (if desired by the owner in this country), and their ruling should be followed, as you can see that a formula based on depth may not take into account the vessel's peculiarity. Furthermore, such associations as The New York Underwriters' will often limit the draft. For full information about the British Board of Trade freeboard see pamphlet "Freeboard Tables" published by them; however, the article by H. A. Everett published in the April, 1917, issue of MARINE ENGINEERING will be found very interesting.

The American Bureau *formerly* published a suggested freeboard allowance which in the cases of the ordinary cargo steamer will give a freeboard roughly one foot greater than that assigned by the Board of Trade. An abstract of this table is given below:

Depth of Hold from Top of Ceiling to Underside of Deck (Main Deck), Feet	Freeboard at Lowest Point of Sheer for Each Foot Depth of Hold, Inches
8	1½
12	2¼
16	2½
20	3
24	3¼
28	3½

"Hurricane deck vessels having no water ports fitted at the second deck, also raised quarter deck vessels, may have less, but suggest that hurricane deck vessels have not less than one-half and quarter deck vessels not less than three-quarters of the freeboard in the table. The depth of hold and freeboard to be measured from the second deck in hurricane deck vessels. . . ."

The writer would suggest that the following formula will give approximately the freeboard for an ordinary cargo vessel of over 20 feet depth, having a normal sheer, the freeboard being measured from the weather deck:

Freeboard = .40 depth — 6.0 (feet)

Depth = depth from top of keel plate to weather and strength deck (foot units).

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PERSONAL MENTION

A. SHEARER, formerly works manager of the Halifax Shipyards, Ltd., Nova Scotia, Canada, has been appointed manager of the Turkish Arsenal, Constantinople, Turkey, controlled by Sir W. Armstrong, Whitworth & Company, Ltd., and Vickers Limited, of Elswick and Barrow, England. When Mr. Shearer became identified with the Halifax Shipyards, Ltd., in 1917 he took over the existing dry dock from the Halifax Graving Dock Company and laid out and began the operation of a four-berth shipyard next to the dry dock on the ruins of the Arcadia Sugar Refinery, which was destroyed by the great Halifax explosion. Here keels for the first two 10,000-ton vessels ever built in Nova Scotia were laid. Having completed that work, Mr. Shearer returned to England and was appointed to his present position.

EDWARD GRANVILLE TUCK, recently appointed as chief surveyor of the American Bureau of Shipping, is a native of the state of Maine. Reared as he was in a shipbuliding community, he began his training at the Bath Iron Works, where he spent five years in learning the details of the business. In that period, begun as an apprentice, he emerged as assistant foreman of hull construction. The Eastern Shipbuilding Company, organized primarily for the construction of the two Northern Pacific mammoths among American ships, the *Minnesota* and *Dakota*, next demanded Mr. Tuck's services, and he was employed throughout their entire construction as foreman in charge of mold loft and fabrication. Having mastered the details of construction in the mold loft and building yards, he became a ship draftsman, and as such has served a number of years in some of the leading American shipyards, including Cramps, Newport News, Fore River and Harlan & Hollingsworth. In several of these yards he has been draftsman in charge. In 1917 he was first employed by the American Bureau of Shipping as a surveyor, and was soon appointed assistant to the chief surveyor for the Pacific coast. In that capacity he became thoroughly acquainted with all the shipyards in the West. Mr. Tuck's appointment to the important position of chief surveyor of the American Bureau came in the nature of a well-earned promotion. His many years of experience in the various branches of shipbuilding, combined with an obliging and courteous disposition, make him peculiarly adaptable for the position which he now fills.

E. G. Tuck

COMMANDER R. D. GATEWOOD, of the Construction Corps, U. S. N., has been selected by Rear Admiral Benson, chairman of the Shipping Board, as director of construction and repair of the Emergency Fleet Corporation, relieving R. L. Hague, of San Francisco, resigned. Commander Gatewood graduated from the Naval Academy in the class of 1903 and from the post graduate course of naval architecture and marine engineering at the Massachusetts Institute of Technology in 1906. He has been in charge of repairs and new construction on both the Atlantic and Pacafic coasts, and for two and one-half years was fleet constructor of the North Atlantic fleet. During the war he was superintendent of motive power for the Panama Railroad in charge of the large shops and dry docks at both ends of the Isthmus and made an enviable record in connection with the extensive repair and refitting work on merchant vessels.

ARTHUR W. KIRTON, contract inspector of the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., sailed for Sweden on the *Olympic* on July 7 to witness the trials of the new Swedish battleships *Drotting Victoria* and *Gustaf V*, which are equipped with Westinghouse geared turbines. Mr. Kirton has traveled all over the world in the interest of the Westinghouse Company and has spent several years in South Africa, Russia and South America. He is well known to a large number of marine men, especially because he has been in charge of the Westinghouse Marine Turbine School at South Philadelphia.

Arthur W. Kirton

COMMANDER JAMES REED, Construction Corps, U. S. N., has resigned from the naval service to become assistant general manager of the Los Angeles Shipbuilding & Dry Dock Company, San Pedro, Cal. Commander Reed was appointed to the Naval Academy from Ohio in 1898, graduating in 1902, and after spending two and one-half years at sea with the North Atlantic Fleet, serving both on deck and in the engine room, principally on the battleship *Alabama*, he was selected for the Construction Corps and ordered to the Massachusetts Institute of Technology for the post-graduate course in marine engineering and naval construction, from which he was graduated in 1907 with the degree of Master of Science. After graduation, Commander Reed spent two and one-half years at the League Island Navy Yard, Philadelphia, principally as shop superintendent, and from 1910 to 1911 was inspector of hull material for the Navy Department, with headquarters in Philadelphia. Early in 1911 Commander Reed was sent to South America on duty "furthering American trade" under the State Department, and upon his return was granted leave of absence by President Taft to accept the position of As-

Commander James Reed

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sistant Director of Public Works of the city of Philadelphia under the reform administration of Mayor Rudolph Blackenburg. In 1914, after an appointment at the Puget Sound Navy Yard as shop superintendent, Commander Reed went to Mexico as fleet constructor on the staff of Admiral Thomas B. Howard, who was then commander-in-chief of the Pacific Fleet. In the fall of 1914 he was ordered to the Mare Island Navy Yard, continuing on duty there principally as new work superintendent in the hull division in connection with the building of tankers, destroyers and battleships until his resignation from the naval service on April 20. Commander Reed is a member of the Army and Navy Club of New York, the University Club of Philadelphia, the American Society of Mechanical Engineers, and upon acceptance of his resignation from the Navy was enrolled in the Fleet Naval Reserve as lieutenant-commander in the Construction Corps.

JAMES P. ROE, engineer and metallurgist, has been appointed general superintendent of the Reading Iron Company, Reading, Pa. Of Welch birth, Mr. Roe began his apprenticeship in the engineering field when he was only twelve years old at the Consett Iron Works, Consett, England, where he went through the pattern shop, machine shop and drafting room and subsequently became assistant mechanical engineer of the Consett Works. Coming to America at the age of twenty-three, he became associated with the Pottstown Iron Company and worked up through the various grades to the position of general superintendent. In 1890 he resigned to become general superintendent of the Glasgow Iron Company's interests, which then comprised the Valley and Glasgow mills. In March, 1898, his sphere was enlarged when the Glasgow Iron Company leased the plants of the Pottstown Iron Company. Mr. Roe is the inventor of the Roe mechanical puddler, the exclusive rights to which for the manufacture of pipe were secured several years ago by the Reading Iron Company. On account of the restrictions on building operations imposed during the war, the plant which the Reading Iron Company built for the purpose of placing the mechanical puddler on a successful production basis was closed for a period of two years. The first of this year the department was again put into operation and it is expected that under Mr. Roe's personal direction the plant will soon be operating successfully on a production basis. Mr. Roe is an active member of the American Iron and Steel Institute, the American Society for Testing Materials, and the British Iron and Steel Institute.

James P. Roe

BRIGADIER-GENERAL FRANK T. HINES, U. S. A., has been appointed Chief of the Inland and Coastwise Waterways Service of the War Department, which is an entirely new bureau created by a recent act of Congress. During the world war General Hines had charge of overseas transportation and later was chief of the Bureau of Transportation, which, under the Army reorganization act, was merged with the quartermaster general's office.

F. B. COLE has been appointed assistant district manager in charge of construction of the North Atlantic District of the United States Shipping Board Emergency Fleet Corporation, with headquarters at 45 Broadway, New York.

WILLIAM B. FERGUSON, who has been connected with the American International Shipbuilding Corporation since its inception, has become associated with the Philadelphia Engineering and Sales Corporation as president.

R. H. COOPER has resigned from the Shipping Board after serving for three years as assistant to Harold H. Ebey, director of operations. He will become vice-president and general manager of the Export Transportation Company, of Baltimore.

THOMAS D. PITTS, manager of the Delaware River District of the Division of Construction and Repairs of the Shipping Board, has been promoted to be manager of construction, succeeding F. P. Baldwin. J. J. Eason has been appointed to succeed Mr. Pitts in the Delaware River District.

E. M. HERR, president of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., was recently decorated with the Order of the Rising Sun by the Emperor of Japan.

VICTOR T. NOONAN, formerly safety engineer at the Fore River, Mass., plant of the Bethlehem Shipbuilding Corporation, has become a public consulting engineer on accident prevention in industry.

ROY S. MAC ELWEE, New York, assistant director of the bureau of foreign and domestic commerce, has been confirmed by the Senate to be director of the bureau to succeed Philip B. Kennedy, whose resignation became effective July 1. Mr. Mac Elwee is the author of *Ports and Terminal Facilities* and a number of pamphlets on foreign trade subjects.

MAJOR GENERAL WILLIAM M. BLACK, who retired from the army last October, has resigned as an advisory engineer with the Shipping Board because of the ruling by the Treasury Department that the board cannot pay the expenses of retired army and navy officers serving with it. General Black was formerly in charge of the engineers' corps of the War Department.

MAX HANSEN, naval architect, marine and mechanical engineer, formerly connected with the McBride & Law Shipyard as manager of construction, has opened an office as naval architect and consulting engineer in Beaumont, Tex. Mr. Hansen has been previously connected with some of the foremost shipbuilding concerns in the United States.

CAPTAIN FRANK E. FERRIS has been appointed special commissioner of the United States Shipping Board and the Emergency Fleet Corporation, with headquarters at 8 Grosvenor Gardens, London, in place of Captain E. C. Tobey, resigned.

H. BIRCHARD TAYLOR, vice-president of the William Cramp and Sons Ship and Engine Building Company, Philadelphia, has been elected president of the Atlantic Coast Shipbuilders' Association. F. P. Palen, vice-president of the Newport News Shipbuilding and Dry Dock Company is vice-president, and W. T. Smith, vice-president of the Merchant Shipbuilding Corporation, treasurer. The administrative council consists of Joseph W. Powell, E. C. Bennett, J. Harry Mull, M. A. Neeland, W. T. Smith, S. M. Henry, F. P. Palen, H. L. Brittain, W. G. Coxe.

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Shipbuilding and General Marine News

Contracts for New Ships — Shipyard Improvements — Engineering Projects—Improved Appliances—Personal Items

AMERICAN SHIPS AND SHIPYARDS ABLE TO MEET COMPETITION

National Foreign Trade Council Optimistic as to the Future of Our Merchant Marine; Government Should Permit Freedom of Action; Some Valuable Suggestions.

In a report of the Merchant Marine Committee of the National Foreign Trade Council, recently presented by Welding Ring, an outlook so encouraging that it may be called optimistic is expressed as to the future of American shipping and shipbuilding. American shipyards, the report states, will be able to compete favorably with foreign yards, and it is held that the revision of the navigation system will enable the operation of American ships on a competitive basis. Sale to foreigners is urged of the less desirable types of vessels owned by the Government, and opposition is voiced to any Government dictation as to trade routes, freight charges or methods of management.

The report, as presented by Mr. Ring, states:

"The National Foreign Trade Council has considered, and from time to time issued statements outlining its views upon the question of the employment and disposition of that portion of our merchant marine built under the auspices of the Shipping Board and acquired as a result of the war. The final declaration of the Sixth National Foreign Trade Convention, unanimously adopted, read as follows:

"'While Government ownership and reasonable Government control of American shipping must continue until some acceptable plan is devised for the transfer of such tonnage to private ownership, we are opposed to any continuance of Government operation, and urge that, consistent with recognized war emergency needs, these Government-owned vessels be allocated to suitable trades and trading routes for operation by any qualified competent American shipping enterprise, under conditions of sale or charter that will permit of their sending the American flag to any port of the world on a fair trading competitive basis with that of any other maritime nation.'

"Among the factors on which this declaration was predicated are the following: The American merchant marine will have increased when the present construction programme of the United States Shipping Board is completed, together with additional vessels laid down by private owners, to approximately eight times the tonnage in the overseas trade on June 30, 1915.

Freedom of Action Urged

"The future of the American merchant marine depends on the opportunities which it will offer to the employment of private capital and private initiative. It is generally conceded among ship owners and shippers that no limitation should be placed upon the absolute freedom of carriers to change their freight rates to suit the competitive conditions of the freight market. The merchants and manufacturers of the United States should be enabled to compete with their rivals in other countries without Governmental intervention or supervision of transportation charges. It is recognized by all that our merchant marine must be used primarily to develop the commerce of the nation as a whole, but as it is generally agreed that this development can be accomplished only under private ownership and management, there should be no dictation as to trade routes, freight charges or methods of management.

"No policy can be successful ultimately which involves the operation of steamers in any service at a loss. Such operation involving a deficit which would necessarily be made up from the national treasury, would amount to the bestowal of a bounty upon most favored commodities or producing communities or substantially a subsidy to such steamship lines, a practice generally condemned as inimical, economically unsound and unnecessary from the standpoint of foreign nations' experience.

Proposal for Sale of Ships

"Little opposition, therefore, has developed to the following fundamentals of a national shipping policy. Legislation should be enacted to enable the proper disposition of as large a proportion as possible of the present fleet owned by the United States Shipping Board, to avoid incurring additional loss to our Government by the further decline of values or freight rates. Such legislation should insure to all purchasers of these ships uniform terms of sale and conditions, and the opportunity of developing plans with relation to the establishment of permanent or temporary trade routes for ships under their own management or ownership.

"An unequivocal policy must be established promptly by legislation providing that sales will be made to all responsible buyers at prices determined by the present cost of construction of vessels of similar tonnage and specifications in the best qualified of American shipyards. It is manifest that this should be the basis of comparison, rather than the cost of production in foreign shipyards, which necessarily varies in respect to the country of manufacture, labor conditions and supply and demand. The terms on which such sales should be made should be such moderate percentage of cash payments as would enable a prompt disposition of these ships without any undue hardship being imposed upon our banking institutions or increasing any stringency of money which may exist at the time of sale.

"The percentage of the periodical subsequent payments should likewise be fixed, with due regard to the present world-wide demand for American exports and the increasing consumption in this country of foreign products which may be expected to insure for a considerable period the existence of profitable freight rates.

"Such period and percentage of payments should give to the buyer a reasonable opportunity to amortize such proportion of his investment over a period of years as would enable the writing down of the original cost of his vessel to a competitive value in later years with any subsequent reduction in the cost of shipping. This period of time should be measurably commensurate with that in which the partial and final payments are to be made.

Chartering Policy Outlined

"It is reasonable to suppose, notwithstanding that such easy terms of payment, although fair alike to the Government and shipping community, may be evolved, that it will be difficult to dispose by outright sale of upwards of 1,500 vessels aggregating some 10,000,000 gross tons within a short period. It is manifest, therefore, that during the process of negotiations for the sale of the complete

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fleet, built and building, vessels unsold must be chartered to competent and responsible operators on equitable terms comparable to the sale price. Such charter term can, of course, take suitable cognizance of the current conditions of the freight market in respect to the trade routes in which the vessels are to be operated, and such charters can be made subject to sale.

"It is not believed that theories with respect to the application of profits derived from charter operations to the purchase price of ships or the partnership of the Government with shipping companies on a profit-sharing basis, will prove practical.

"The operations of the Shipping Board, or such department as may be evolved, should be confined to the outright sale and actual charter of the vessels in accordance with such legislation as may be enacted. It is the opinion of many of our most able shipping men that having regard to a considerable surplus of ships already built, and now building, of a character not entirely suited to the requirements of our overseas commerce, no restrictions should be imposed on the sale of such vessels to foreign buyers. It is manifest that the exigencies of the world war required the construction of hundreds of vessels of a size, tonnage and equipment uneconomical to operate as important units in the carrying of our overseas commerce, but well adapted to meet special trade conditions in other parts of the world.

SALES TO FOREIGNERS

"There is no advantage to this country in the effort to operate uneconomical ships, when by their prompt sale the pressing necessities of other nations now suffering for lack of ocean transportation facilities can be alleviated. Moreover, the disposal of such vessels would enable their replacement by the building in American shipyards of vessels of tonnage and construction suitable for overseas commerce. Such method would give to shipyards equipped to produce competitive vessels of types required for our foreign trade greater assurance of continued employment.

Suggestions have been made of the imposition of additional duties on goods imported in foreign bottoms, or, what is tantamount, by the reduction of duties on goods imported in American ships. The liability to reprisals from such procedure requires careful consideration. Nor should it be forgotten that the present demoralization of European productivity and exchange, in which problems the future of our export and import trade is inextricably involved, can be sensibly lessened by affording to the European nations the immediate use of transportation facilities which are vital to their national prosperity and even their existence.

"The retention of such surplus tonnage by us may merely impose a glut of unnecessary and unserviceable ships on our market, depreciating the value of the suitable vessels and hindering the working out of a programme of prompt disposition at favorable prices.

"It is well known that the shipyards of the principal maritime nations are filled to capacity for a long time to come, and we must consider not only that this establishes a favorable market for the disposition of ships unsuitable or unnecessary for our needs, but we must picture the effect of the selfish retention of such ships on our part as against the exigent demand for them, especially by European nations, some of whom were our associates in the war.

SHIPBUILDING SITUATION FAVORABLE

"The Foreign Trade Council has already placed on record its conviction that American shipyards will be able to produce tonnage at rates and under conditions that will compare favorably with those obtaining in foreign maritime countries. There will be no return, for some time at least in any country, of so-called pre-war prices of materials and labor. Shipbuilding materials and equipment are on a lower level in the United States, since the signing of the armistice, than in any other producing country.

"There is a present disparity in favor of the American shipbuilder of approximately $40 per ton in the price of steel shipbuilding material, and while wages in most foreign shipyards are appreciably lower than in ours, the factor of efficiency compensates to a large extent. It is therefore believed that at least for the extended period in which there should continue a good demand for vessels of the size and construction appropriate to the needs of overseas commerce, American shipbuilders can compete with the world. As the restrictions on the building of ships for foreign account have been removed during the past year, it is difficult to understand the contention that all the Shipping Board vessels, irrespective of size and suitability, should be reserved exclusively for operation under the American flag.

"The investigation of the American navigation system which the Shipping Board was directed by its organic act to effect is now under way. It should be completed with the least possible delay, and the revision and improvement of the navigation system contemplated by the Shipping Act should enable the operation of the American merchant marine on a competitive basis."

U. S. to Build for Mexico

Gen. Salvador Alvarado, Minister of Finance in the cabinet of the provisional President of Mexico, Adolfo de la Huerta, arrived in San Antonio, Tex., recently from Mexico City, and said he was on a threefold mission to the United States. He expects while in New York to ratify contracts for the construction of approximately fifty ships ordered from American builders.

Contracts for rolling stock for Mexican railroads are also on the list.

MARINE ENGINES IN CHINA

Good Demand Reported for High Speed Low Weight Equipment

United States consular reports from Canton and Hongkong, China, with reference to marine engines, show that a large number of the tugs used in the district are idle because of the prohbitive price of coal, and that orders for crude oil engines have been placed with a native company. To convert these steam tugs a crude-oil engine developing 120 horsepower would be needed. It is suggested that manufacturers of heavy-duty engines who are interested correspond with the Canton consulate.

Most of the motor launches owned in Canton are equipped with American motors, sold by non-American firms who could not get European motors. One Canton firm has sold twenty American motors in the past ten months, and plans an extensive marine motor import department, and American engines will be handled if satisfactory arrangements can be made. A British firm in Hongkong has sold about forty engines in this district. This firm has no office in Canton. The most popular American motor which this firm sold during the war (a four-cylinder marine motor, developing 24 brake-horsepower at 450 revolutions per minute) is sold at $2,400, Hongkong currency. Hongkong currency $100 has not been worth less than $75, United States currency, during the past twelve months. Orders for this engine sent direct to the factory would result in placing this engine on the market in Canton at a cheaper price.

Another British firm, which holds the sole agency for two famous American marine motors, manufactures marine motors at its factory in Shanghai. With the exception of one firm, which is located in Canton, the non-American firms, which have acquired sole agency privileges for American marine motors, have not actively pushed the sale of marine engines. Their position has been one of receiving orders, not of seeking them.

Some two years ago the demand for light marine engines was confined to 4 to 8-horsepower, one or two-cylinder, two-cycle engines. But now every buyer who contemplates having a launch built wants an engine that will produce a speed of at least 15 miles an hour. Thus the type of engine wanted is a high-speed, low-weight kerosene engine, with high-tension magneto ignition, arranged so that the cylinder heads are removable. Engines of this type, developing from 10 to 35 horsepower, can be sold in increasingly large numbers. High-powered engines are purchased by business houses for the use of members of their staffs; the real market for speed-model marine engines exists among the official and wealthy-class Chinese. They are fast learning the charms of a speed boat. Five hydroplane boats built by a young American-Chinese, which develop about 30 miles an hour,

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have made speed boats the desideratum of hundreds.

The river, with its two reaches and deep, broad channel, has long been the playground of the wealthy. Flower boats, so called, which are floating restaurants, are being modernized. Electric lighting units, low-speed marine motors and plumbing are being installed.

In the Hongkong district there are no means of ascertaining the value of the present trade in internal combustion engines. The imports of these engines and plants into Hongkong in 1918, reported by the statistical department of the Hongkong Government, were valued at $1,053,425, of which a value of $66,626 were re-exported. Almost all of these imports came from Great Britain.

On the other hand, the imports of such engines in the first three months of 1919 were valued at $39,259, of which machines to the value of $27,696 came from the United States, representing commercial demand. Most of these imports were internal combustion marine engines, for which there has been a steady, strong demand during the past five years.

The only promising means of introducing these engines in this field is through the important commision houses. Connections will probably not be easily obtained, but a strong firm with plenty of energy and a reasonable amount of advertising help from home ought to do a good business from the start. At present American engines of this type are in high favor.

TODD MEN GET STOCK

$1,000,000 Distribution Among Faithful Employees

William H. Todd, president of the Todd Ship Yards Corporation, on July 1 fulfilled a promise he made four years ago by distributing among 727 employees at the various plants of the corporation paid-up stock to the value of approximately $1,000,000.

On July 1, 1916, he offered stock to the workmen who stuck by him during the four following years in proportion to their responsibility, and on July 1 this year he made good his promise. The stock had been deposited in the names of the men who subscribed to the agreement, and they acquired 25 percent of its par value each year until the end without cost to themselves, collecting dividends in the meantime.

The distribution was made at the Robins and Tebo plants in Brooklyn and the Tietjen & Lang yards in Hoboken. Mr. Todd was the recipient of many valuable tokens of the esteem in which he is held by his employees, and expressed regret that more had not come in when the idea was first broached, but intimated that there would be another chance if the company could see its way clear to put it into effect.

One feature of the arrangement is that one-half of the stock delivered may be deposited with the company, and at the end of the next four years will be returned to the men who stay on, doubled, they drawing any dividends that may be declared. The Todd stock is now quoted around $165 a share and the bonuses ranged from $165 to over $8,000.

The corporation stock for the year ended March 31, 1920, after depreciation, Federal taxes and sinking fund were provided for, showed earnings of $66.89 a share, as compared with $11.93 per share earned in the previous year.

As explained by an official of the company, the plan was not conceived as a bribe to the employees to forsake their unions, but by making them partners in the business to arouse their ambition and thus make Todd work continue on its present high plane.

The gifts to Mr. Todd included a diamond studded watch from the office force of the Robins plant, and a gold fob with Masonic emblems from the other offices, a handsome golf outfit from the Tebo Yacht Basin, a beautiful silk American flag from the Clinton plant, a silver mounted, fully equipped, traveling bag from the White Fuel Oil people, a large gold tablet, suitably inscribed, from the Tietjen & Lang forces, and a big, three-handed silver loving cup from the Seattle and Tacoma yards.

Mr. Todd later started for Seattle to complete the distribution of stock among the employees in the Pacific yards who have stuck to their jobs and taken advantage of the offer made four years ago.

AMERICAN ENGINEERS PLAN CARGO SHIP WITHOUT RIVETS

Big Saving of Materials, Labor Costs and Cargo Space Claimed for Welding System, with Increased Strength

Following the recent launching of a 500-ton rivetless steamer in England, J. S. Dudley, research engineer, and L. L. Holladay, electrical engineer of the Merchant Shipbuilding Corporation, owners of yards at Harriman and Chester, on the Delaware, announce that they have completed designs for an 8,800-ton Emergency Fleet type freighter, to be built without rivets. The hull will be 401 feet long and 54 feet molded breadth, with a displacement of 12,231 tons. Mr. Holladay describes the ship as follows:

"The hull is electric welded throughout and therefore wholly without rivets in its construction. In addition to certain beams, keel, keelsons, etc., running longitudinally, the bottom shell plating, sheer strakes and deck plating run longitudinally; however, the side shell plating, top plates to double bottom and bulkhead plates run transversely or vertically. All plates are abutted without lapping straps or angles and then are welded with a joint 95 to 100 percent as strong as the abutting steel members; which results in the elimination of all overlapping steel in plating, liners, angle irons for joining structural parts, stapling and rivets.

"As this material was added originally only incidentally or unavoidably, and for no purposes of strength or stiffness, therefore, none or only minor compensation need be made for its removal. We may, therefore, expect a saving of steel due to elimination about as follows:

Overlapping of plates at points	5½% or 160 tons
Angle-irons uniting structural parts, stapling, etc.	7 % or 203 tons
Liners	1 % or 29 tons
Rivet heads	2 % or 58 tons
Total	15½% or 450 tons

"The thickness of shell plates remains the same as in the standard riveted ship, notwithstanding the efficiency of the welded joint is 95 percent, whereas the efficiency of the riveted joint averages only about 75 percent. This course is conservative, and possibly preferable, until experience has demonstrated that thinner plates may be used with safety. The largest commercial sizes of plates are used to reduce the amount of welding to a minimum and keep strength up to a maximum.

"In order to enable welders to work with the greatest ease, speed, efficiency and reliability, a maximum of welding is to be done on a flat, horizontal surface, a minimum on a vertical surface, and overhead welding is practically excluded. Owing to the elimination of about 450 tons of useless metal in the hull, the initial cost of material will be reduced accordingly. By the substitution of electric welding for riveting a great deal of labor will be saved, as follows: Mold loft work, laying out of shapes and plates, transportation and handling of steel considerably reduced, and punching, reaming, drilling, riveting and calking eliminated.

"By increasing the thickness of plates by about 15 percent to make up for the steel eliminated, and considering a welded joint has an efficiency of 95 percent against 75 percent for a riveted joint, the electric welded ship will be 45 percent stronger than the riveted ship for exactly the same weight, or this excess may be set up against any fancied weakness in the welded ship.

"To sum up, the electric welded ship will contain about 15 percent less steel, will take 40 percent less labor, will take 25 percent less time for construction, will take 2 percent less power for propulsion, will be cheaper to maintain, and be of 5 percent greater capacity.

"The outstanding and unquestionable net gain of such a welded ship over its counterpart assembled by riveting is the increase in cargo-carrying capacity of more than 500 tons, which, when translated into earnings, represents little less than a revolution in shipbuilding and ship transportation."

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AMERICA BUILDING FEWER SHIPS

World's Total Construction Falls Off Four Percent

Although nearly a million and three-quarters gross tons less of shipping are being built in the United States to-day than a year ago, the reduction in the world total under construction is less than 4 percent, says a statement just issued by *Lloyd's Register of Shipping*. Returns from all countries for the quarter ended July 1 show an aggregate of 7,720,000 tons under way, compared with 8,017,000 at this time last year.

The sharp decline in American building has been almost completely offset by gains made by practically all the other maritime countries. On July 1, 1920, there was under construction in the United Kingdom more than a million gross tons in excess of the July 1, 1919, figure, while all other countries combined, exclusive of the United States, showed an increase of over 400,000 tons. The American aggregate of 3,874,000 tons a year ago has now declined to 2,105,000 tons.

To-day, therefore, according to the returns, the United States is building 1,472,000 tons less than the United Kingdom, whereas, a year ago America led by 1,350,000 tons.

A notable feature of the returns from all countries is the indication that the United States is taking effective steps to remedy its shortage of larger-sized vessels. The 366 steel steamers building in American yards represent an average per ship of 5,609 gross tons, as against 4,012 tons for the 888 British vessels and 2,985 tons for the 655 building for the rest of the world.

Lubrication of Hack Saws

To prolong the life of hack saw blades and to increase their cutting speed it is necessary to use some form of lubricating compound. The purpose of a lubricating liquid is not so much to lubricate the work as it is to keep the blade cold. The blade is comparatively thin and loses its temper easily, especially since high cutting speeds on machine-driven saws are maintained. For this reason there should be a constant flow of water or compound over the work except in the case of iron castings.

In order to determine the best lubricant for the efficient operation of hack saws, the L. S. Starrett Company, Athol, Mass., recently conducted a series of tests which resulted in developing a compound consisting of one quart of sal-soda thoroughly dissolved in ten gallons of cold water, to which was added a mixture of four quarts of mineral and lard oil.

A New Diesel Engine

The Worthington Pump & Machinery Corporation, 115 Broadway, New York, announces the development of a 2,400-indicated horsepower marine Diesel engine. This engine, built at the Snow-Holly Works, Buffalo, N. Y., of the Worthington Company, is of six-cylinder, 4-cycle type, having a cylinder bore of 29 inches, stroke of 46 inches, and operating at 120 revolutions per minute. This engine has proven so successful in its preliminary tests that the Worthington Company is prepared to produce this engine on a commercial basis, as well as to carry through the design of such other sizes of marine Diesel engines as it may require for installation in American motor ships.

Drop-Forge Combination

The drop-forge and wrench factories of the Whitman & Barnes Manufacturing Company, of Chicago and St. Catherine's, Ont., have been merged with J. H. Williams & Company, of Brooklyn. This consolidation leaves the Whitman & Barnes Manufacturing Company as exclusive twist drill and reamer manufacturers. The general office of the company is at Akron, Ohio. J. Harvey Williams will be president of the new company. A. D. Armitage, president of Whitman & Barnes, will be vice-president of J. H. Williams & Co., and W. E. Rowell, Whitman & Barnes' secretary, becomes Western manager of J. H. Williams & Company at the Chicago factory.

The Whitman & Barnes Company will remain in the twist drill and reamer business, retaining its Akron, Ohio, factory, and the entire time and energies of its organization in the future will be directed exclusively to their manufacture. A new and enlarged plant will be constructed, plans for which are rapidly developing.

2,241 Vessels Built in Last Fiscal Year

During the fiscal year ended June 30, the total shipping built in the United States (including a small tonnage built for foreign owners) and officially numbered by the Bureau of Navigation, Department of Commerce, aggregated 2,241 vessels of 3,860,484 gross tons, compared with 2,158 vessels of 3,734,741 gross tons during the preceding fiscal year.

The peak of production, under the vast shipbuilding appropriations by Congress to win the war was reached in the autumn of 1919, and the following winter, when, from September, 1919, to February, 1920, the output was at the rate of 4,250,000 gross tons a year. This great rate was maintained through the proceeds of Federal taxation and of the sales of Liberty bonds applied by Congress to shipbuilding, involving a total expenditure for ships since June 30, 1917, of about $3,000,000,000, with an annual interest charge of about $150,000,000.

New Fletcher Dry Dock

A big addition to New York's ship repairing facilities has been made by the delivery to the W. & A. Fletcher Company plant, in Hoboken, of a steel dry dock, built by John Monks & Sons and the American Bridge & Foundry Company.

AMERICAN BUREAU LEADS

Classifies 60 Percent of United States Ships

Of the tonnage now building or contracted for in the United States nearly 60 percent has been placed exclusively under the supervision of the American Bureau of Shipping, according to a detailed tabulation prepared by J. B. Crowley, statistician of the bureau. Through the ruling of the Shipping Board limiting the classification of its tonnage to the American Bureau, which ruling was made permanent through the enactment of the Merchant Marine Act of 1920, the lead hitherto held by Lloyd's Register of Shipping in this country has been eliminated. The American Bureau is now classing about a million gross tons more of American vessels than the older organization, the totals being 1,804,000 for the American Bureau, 833,000 for Lloyd's, and 362,000 dual.

In his statement, which reviews the shipbuilding position as of July 1, Mr. Crowley puts the known total of vessels under construction or contracted for both Government and private account at 3,119,000 gross tons. This is considerably in excess of the aggregates of construction work recently announced by the Atlantic Coast Shipbuilders' Association and the United States Bureau of Navigation. Mr. Crowley's total, however, includes Shipping Board tonnage for which the keels have not been laid, and also takes in the smaller classification societies whose reports do not figure in the totals of the Atlantic Coast Association. The seeming discrepancy is thus explained. According to the American Bureau's statement, building for private account is 390,000 tons in excess of that for the Government.

In the lassification of steel tonnage building for private account, Mr. Crowley's figures show, Lloyd's Register still leads, with 816,000 gross tons, in comparison with 415,000 for the American Bureau. There are also a number of instances in which the same ships are being classed by both societies. This dual classification aggregates 362,000 gross tons, so that the two leading organizations are supervising altogether the construction of 1,593,000 tons out of the total of 436 vessels of 1,690,000 tons given as under way for private account.

Presented in gross tonnage, the Government programme shows a total yet to be completed of 226 vessels of 1,364,000 gross tons, of which 1,272,000 tons is composed of 210 steel contract vessels, 10 requisitioned steel ships account for 62,000 tons, and there are six concrete vessels of 30,000 tons. The figures include 26 steel contract ships, of 263,000 tons, for which the keels are to be laid.

The grand total of 712 vessels, aggregating 3,119,000 gross tons, for both accounts, indicates that the work in sight, at the rate of last year's construction, may keep the shipyards employed for about ten months.

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PERSONAL AND BUSINESS NOTES

Mr. E. D. Mitchell has been appointed manager of the New York office of Alfred Herbert, Ltd., 54 Dey street, in place of Mr. W. J. Fuller, recently resigned. Mr. Mitchell is also a director of the Société Anonyme Alfred Herbert, of Paris.

Russell A. Griffin, general sales manager of the National Pole Company, died July 14 of pneumonia. Mr. Griffin was for many years connected with the American Telephone & Telegraph Company, and later with the Western Electric Company before going into the pole business.

"Ad astra per ardua," the motto of the British Flying Corps, has become literally true in the case of Leroy S. Starrett, president of The L. S. Starrett Company, of Athol, Mass., who recently celebrated his 84th birthday by a "trip to the clouds" in a hydroplane at St. Petersburg, Florida.

The consolidation is announced of Westinghouse, Church, Kerr & Company, Inc., and Dwight P. Robinson & Company, Inc., under the name of Dwight P. Robinson & Company, Inc., engineers and constructors, with offices at 125 East Forty-sixth street, and 61 Broadway, New York.

The Worthington Pump & Machinery Corporation, 115 Broadway, New York, announces the purchase from the Platt Iron Works, of Dayton, Ohio, of their drawings, patterns, jigs, templates, special tools, good will and name on oil mill machinery, hydraulic turbines and waterwheels, feed-water heaters, and high-pressure air compressors.

The Emergency Fleet Corporation announces that a portion of the main floor of 45 Broadway, New York, was leased by the Corporation to the United States Mail Steamship Company for one year, beginning July 19, 1920. The lessees recently entered into a charter contract with the United States Shipping Board covering a five-year period.

Seattle has gained another advantage as a shipping center by being made headquarters of a new shipping district to be known as the Puget Sound and Columbia River district. This action by the Shipping Board is the result of a strenuous fight on the part of commercial bodies of the Pacific Northwest to have the district removed from the jurisdiction of the San Francisco office.

The new building of the Chicago Fuse Company, on the former Otis Elevator Company property at Laflin and Fifteenth streets, Chicago, has a total floor space of 125,000 square feet. It is a modern, daylight, two-story factory structure, with a four-story office section, protected throughout with sprinkler system. William W. Merrill, vice-president and treasurer of the company, states that the building has been entirely remodeled in accordance with the most approved ideas of industrial engineering practice and the most modern equipment installed. With the additions contemplated, the buildings and equipment will represent an investment of more than a half million dollars.

The Oxweld Acetylene Company, of Newark, N. J., Chicago and San Francisco, is justly proud of the distinguished service award tendered the company by the War Department of the United States. The award reads: "The War Department of the United States recognizes in this award for distinguished service the loyalty, energy and efficiency in the performance of the war work by which the Oxweld Acetylene Company aided materially in obtaining victory for the arms of the United States in the war with the Imperial German Government and the Royal Austro-Hungarian Government." The award is signed by the Secretary of War and the Assistant Secretary of War, Director of Munitions.

The steamship *Provincetown* was launched on June 19 at the Groton Iron Works, Groton, Conn., with her hull 100 percent complete and outfitting in excess of 90 percent. The *Provincetown* is a single-screw cargo steamer of the shelter deck type, with a poop and forecastle, and with machinery amidships. For handling cargo she has two steel masts with four five-ton booms on each, and two derrick posts, each with three-ton booms, all on the shelter deck. On the after side of the foremast there is one thirty-ton cargo boom. Accommodations for the officers are in a steel deck house amidships, and the crew is berthed in the forecastle and poop in cubicles. She will carry a crew of sixty men. She is built to develop a speed of 10½ knots, and is propelled by a compound turbine of 2,800 shaft-horsepower, the propeller speed being 90 revolutions per minute.

The yard of the Morse Dry Dock & Repair Company, Brooklyn, received thousands of visitors during the first week in July, when the American cup defender *Resolute* and the challenger, Sir Thomas Lipton's *Shamrock IV*, occupied the big 30,000-ton dock of the company at the same time. Official measurements of the cup contenders were taken while they were on the dock, and incidentally repairs were made to the *Shamrock IV*. The Employees' Association of the company tendered a reception to Sir Thomas Lipton, members of the New York Yacht Club and the commanders and crew of the *Resolute* and *Shamrock* on Wednesday evening, July 7, in the yards of the company. An out-door stage was erected, and powerful arcs were installed. The programme included vaudeville, boxing and movies, including views of the activities of the Morse Company. Sir Thomas Lipton manifested great interest in the big dry dock, and was frank to say that there was "nothing like it in England."

TRADE PUBLICATIONS

Tumbling Mills.—Tumbling mills of all types, producted by the Whiting Foundry Equipment Company, Harvey, Ill., are described in detail in this pamphlet. Numerous illustrations show the machines in operation in various foundries throughout the country. The catalogue will be mailed on request.

Marine Auxiliary Machinery.—Catalogue "P" issued by the McNab Company, Bridgeport, Conn., describes the construction and operation of the principal machinery auxiliaries installed in modern vessels. Among other devices produced by the McNab Company which are given in detail are hand and steam-steering apparatus, Brown's hydraulic-steering telemotor, steam cargo winches, steam anchor windlasses, ash hoists, Stone's hydro extractor, steering wheels, pedestals and the like.

"CO" Marine Oil Engines.—To inform the marine field of what has been accomplished in the past few years by the Fairbanks-Morse Company, Chicago, Ill., a catalogue designated 125-C has been issued by this company. The construction and records of operation of marine oil installations are given for units, from 30 horsepower to 300 horsepower. The catalogue contains a description of various types of ships throughout the world which use Fairbanks-Morse engines.

The Sign the World Knows.—This pamphlet, issued by the Vacuum Oil Company, 61 Broadway, New York, is intended for the information of marine engine operators and owners in all parts of the world who find it necessary to study the problem of lubrication. In addition to a general description of the various oils that are needed to insure the proper lubrication of marine machinery, the pamphlet contains a list of seaports throughout the world in which representatives of the Vacuum Oil Company are located, and where oil supplies may be obtained.

Air Compressors.—The first edition of the Pennsylvania Pump & Compressor Company's (Easton, Pa.) Bulletin No. 100 has just been issued describing "Pennsylvania" Class 3-A power drive, single stage, straight-line air compressors. In the pamphlet the general specifications are listed, special attention having been given to the description of a new type ring plate valve and oil float gage used to determine the level of oil in the crankcase. Other features of these compressors, as noted in the Bulletin, are a solid forged crank shaft, a forged connecting rod with solid box eyes and removable bronze shell main bearing.

Reclaiming Crank-Case Oils.—Catalogue No. 102 of the De Laval Separator Company, 165 Broadway, New York, describes the application of the centrifugal principle in reclaiming crank-case oils from all types of internal combustion engines. In the larger installations great quantities of lubricating oils are used, so the matter of oil purification and reclamation is of great importance. The De Laval centrifugal oil purifier has proved to be an efficient means of recovering otherwise waste oil and a description of various types and capacities of this machine is given in detail together with an outline of its operation.

Marine Equipment.—Geared turbines, auxiliaries and refrigerating machines are described in a bulletin issued by the Poole Engineering & Machine Company, Baltimore, Md. This company has made a specialty of small horsepower units of aluminum construction for installation in small boats and this as well as larger installations is described in detail, special attention being given to features of the design of both the turbine and gearing. Some space is devoted in the catalogue to the description of the vertical deck pump drive consisting of a single stage steam turbine and reduction gear. A similar drive may also be applied to bilge pumps. A description of another device of this company, the Ideal Refrigerating Unit, is also given in the catalogue.

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Marine Construction News of the Month

Ship Contracts—New Ship Concerns and Shipyard Improvements—Terminal Projects—Government Contracts

SHIPS AND SHIPYARDS

Fabricating Shop, Newburgh, N. Y.—The Newburgh Shipyards, Inc., plans to build and equip a fabricating shop.

Shipyard Sold, Jacksonville, Fla.—The St. Johns River Shipyards have been bought by the Gibbs Gas Engine Company.

Dry Dock, Pascagoula, Miss.—The Gulf Ship Company is to build a drydock at its Pascagoula plant on the Pascagoula River.

Tankers, Argentine, S. A.—The Argentine Government is in the market to buy two oil tankers in the United States and to build two others.

Tanker, Newburgh, N. Y.—The Tank Shipbuilding Corporation, is building a tank steamer of 1,000 gross tons for the Sunset Fuel Oil Company.

Cargo Vessels, Pensacola, Fla.—The Pensacola Shipbuilding Company has secured a contract with an English concern for five 9,000-ton cargo vessels.

Tanker, Chester, Pa.—The Sun Shipbuilding Company is building a bulk oil steamer of 6,000 gross tons for Benham & Boyesen, 8 Bridge Street, New York.

Machine Installation, Perth Amboy, N. J.—Electrically operating pumping machinery, valves, etc., are to be installed by the Perth Amboy Dry Dock Company.

Capital Stock Increased.—The Coastwise Shipbuilding Company, Andrew Street, Baltimore, Md., has increased its capital stock from $2,000,000 to $300,000.

To Sell Shipyard, Jacksonville, Fla.—Negotiations are in progress for the purchase of the Merrill-Stevens Shipbuilding Company's plant from the U. S. Shipping Board.

Shipyard for Sale, Baltimore, Md.—The Shipping Board is arranging for the sale of the Maryland Shipbuilding Company's plant at Soller's Point, comprising 51 acres.

Shipyard Extension, Elizabeth, N. J.—The Bethlehem Shipbuilding Corporation is taking bids for a three-story building at its yards on Front Street, known as the Moore plant.

Increase of Capital.—The William Cramp & Sons Ship & Engine Building Company, Richmond & Norris Streets, Philadelphia, has increased its capital from $6,250,000, to $20,000,000.

Barges, Kearney, N. J.—The Moore plant of the Bethlehem Shipbuilding Corporation, Ltd., has received an order for two 2,500-ton barges from the Western Maryland Railroad Company.

Ship Repair Plant, Newport News, Va.—The Atlantic Ship Service Corporation has been chartered with a capital of $25,000. Frank Richardson, president, and H. R. Lackey, secretary.

Revising Steamer Plans, New York.—Theodore E. Ferris, naval architect, 30 Church St., is reported to be revising plans and specifications for two 400-foot, 15-knot steamers for the "Red D" Line.

Barges, Jacksonville, Fla.—The Gibbs Gas Engine Company is building six barges for M. Garcia, two of which have just been completed. They will be towed to Cuba and used in the sugar industry.

Warships, Japan.—Nine warships have been ordered from the Kawasaki Dockyard and the Ishikawajima Shipyard. The former is to build one cruiser and two destroyers, and the latter six destroyers.

Lighters, Jacksonville, Fla.—The Jacksonville Shipping Corporation is having six lighters built for use in Cuban Harbors in unloading freight. They will be 30 x 80 feet, and carry 100,000 feet of lumber.

To Enlarge Plant, Mobile, Ala.—The Chickasaw Shipbuilding & Car Company plans to spend large sums within the next few months in improvements and additions. A factory to make ships' furniture is planned.

Ford May Buy Shipyard, Detroit, Mich.—It is reported that Henry Ford may take over the Detroit yard of the Great Lakes Engineering Works. Other yards of the company are at Ecorse, Mich., and Ashtabula, Ohio.

Ore Boats, Cleveland, Ohio.—The American Iron & Steel Corporation, Engineers' Building, will build three 12,000-ton boats for carrying ore to its plant. It is a subsidiary of the Lake Superior Iron Ore Company.

Barge, Orange, Texas.—The National Shipbuilding Company will soon start work on a 125-ton barge on the deck of a 300-foot x 40 foot barge, being constructed for the National Oil Transport Company for use in the oil trade.

To Sell Shipyard, Savannah, Ga.—The Foundation Company, Woolworth Building, New York, offers for sale, as a whole or in parcels to suit purchasers, all the plant, ship equipment and other material at their No. 5 shipyard.

Converted Oil Burner, Seattle, Wash.—The new Japanese-built steamer Eastern Importer has been delivered to the Shipping Board. She will be converted into an oil burner at one of the Seattle yards at an expenditure of about $80,000.

Tankers, Seattle, Wash.—The keel for the first 12,000-ton tanker to be built by the Northwest Bridge & Iron Company, for the Swiftsure Oil Transport Company was laid recently. The company has seven of these vessels, which will be of the single-screw type, to build.

Launches First Ship, Victoria, B. C.—The Harbor Marine Company, Ltd., launched its first ship, the Canadian Winner, recently, and a keel for another was laid as soon as the first was off the ways. The latter is a car ferry for the Canadian Pacific Railway Company.

New Shipbuilding Company, Finland.—A new Finnish shipbuilding company has been formed in Abo with a capital of 4,000,000 Finnish marks. The company proposes to build sailing ships with auxiliary motors, and steel vessels of from 1,500 to 2,000 tons deadweight.

Tankers, San Francisco, Cal.—Contracts for building six big tankers for a British oil company, and two for the Standard Oil Company of New Jersey, have been let to the Western Pipe & Steel Company, and they will probably be built at the Schaw-Batcher shipyards, San Francisco.

Fabricated Ships, Italy.—The Italian Government has placed an order with a foreign shipbuilding firm for what is called knock-down steamers. The fabricated material will be shipped to Italy and put together at Palermo. Purchases already made amount to 775,000 tons of material.

Liners, Glasgow, Scotland.—Harland & Wolff are beginning the construction of two liners for the Australian service, one for the P. & O. Line of 13,000 tons of the P. & O. "B" type, of which Harland & Woll are reported to have five on order, and a 12,000-ton vessel for the Aberdeen Line.

Wants Tanker Plans, San Francisco, Cal.—W. W. Johnson of the Union Construction Company is in the east to secure plans and specifications for the construction of a number of tankers for Coast oil companies. How many are wanted is not given out, but they will go into the Pacific oil carrying trade.

To Repair Turbines, Brooklyn, N. Y.—With the addition of a balancing gear to the equipment of its large machine shop, the Morse Dry Dock & Repair Company is now enabled to undertake complete turbine repairs, and is the only ship repair yard in the port of New York possessing such equipment.

Tankers and Tugs, Port Richmond, N. Y.—The Staten Island Shipbuilding Company, is building six 2,000-horsepower ocean tugs for the United States Navy; one tank ship for the Tidewater Oil Company and one tank ship for the Galena Oil Company, and will have the ways ready shortly for two 10,000-ton ships.

Floating Drydock, Chester, Pa.—The Sun Shipbuilding Company has begun work on the basin for its proposed 10,000-ton floating drydock, and hopes to have the dock in operation by March, 1921. The basin is being built large enough so that another dock of any necessary size may be added if business warrants.

Shipbuilding, Germany.—The German Reichstag has appropriated 98,000,000 marks to be used for the rehabilitation of merchant marine. Under provisions of the treaty of peace, the German Government must arrange for the construction of 200,000 tons of new ships annually for five years to be turned over to the allies.

Cargo Vessels, England.—Seven new ships are under construction for the Royal Mail Steam Packet Company, London some of which will be put into the company's South American service. Two others are being specially constructed for the frozen meat trade and will be fitted with the most complete freezing installation yet invented.

Steamer Wanted, New York.—The Isle of Pines Steamship Company, 225 Fifth Avenue, is in the market for a freight and passenger steamer, from 135 to 150 feet long, 28 to 36 feet beam, and loaded draft not to exceed 7½ feet. The vessel will be used for the run between Batabano, Cuba, Nuevo Gerona and other ports on the Isle of Pines.

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Shipyard Sold, Tacoma, Wash.—The buildings and supply of timbers, and a large amount of tools of the Wright Shipyards have been sold to the Garrish Supply Company, and Donald McGregor, of Tacoma, machinery supply dealers. The ways and buildings of the yards will be razed or sold unless some of the building should be used for machinery storage.

Rebuilding Barge, Sturgeon Bay, Wis.—The Leatham & Smith Towing & Wrecking Company is rebuilding the Pere Marquette, which was converted a couple of years ago into a barge, renaming her the Wisconsin. The vessel will have a boiler and engine installed, and be made into a package freighter for the Chicago, Milwaukee & Michigan City Line, Milwaukee, Wis.

For Floating Steamer, Alpena, Mich.—Tenders are solicited for floating, righting and delivering the steamer D. R. Hanna sunk by collision in about 23 fathoms of water off Alpena in Lake Huron. Tenders for the purchase of the vessel as she lies are also solicited. For terms and particulars address R. Parry-Jones, Lloyd's Agent, Kirby Building, Cleveland, Ohio.

Schooner, San Francisco.—Frank Stone has received a contract from Fanning Island, Ltd., a British concern having trading stations on Fanning and Washington Islands, for the construction of a three-masted schooner to carry ten first-class passengers as well as cargo. She will have a 130-horsepower auxiliary engine, with electricity for cabin fans, etc., and other first-class equipment.

Contracts for Tenders, City Island, N. Y.—Kyle & Purdy ha e contracted with the International Petroleum Company for a 132-foot steel maintenance tender; it will have 450 horsepower fore and aft compound inverted engines, 18 x 38 x 26 inches stroke, with one three-furnace Scotch boiler; also for a duplicate of this vessel with the Atlantic Gulf Oil Company. These are to be used as buoy tenders in South American waters.

Shipyard Extension, Baltimore, Md.—The Union Shipbuilding Company is rapidly expanding its repair facilities to take care of the increasing Baltimore tonnage. A new marine railway, capable of accommodating vessels up to 10,000 tons deadweight, is being pushed, and will be ready for operation within a few months. Other developments include the doubling of the present machine shop and the erection of overhead crane systems over all ways.

Barge Steamers, Buffalo, N. Y.—The Inland Marine Corporation of Buffalo and New York, will build ten barge steamers of steel, with compound oil burning engines fore and aft, having a capacity of 650 tons each. These barges will not be flat-bottomed boats, but will be slightly rounded with a light keel attached, making them seaworthy in the open waters between New York and Baltimore. Plans for fifty modern barges are also being worked out.

Drydock, Kearney, N. J.—The Federal Shipbuilding Company will construct a floating drydock capable of lifting a 12,000-ton vessel, 425 feet long, to be placed in the fitting-out basin of the company at its plant on the Hackensack River, near the head of Newark Bay. About $1,500,000, including the cost of two tugs and additional plant facilities made necessary by the project. The dock will be built with steel wing walls and wooden pontoons.

Barges, Mobile, Ala.—Two unfinished hulls begun during the war by the Murnan Shipbuilding Company have been bought by the Eastern Transportation Company and will be converted into ocean-going barges. The Murnan plant has also begun work on a $500,000 contract calling for 12 wooden oil barges of 7,500 barrels capacity, and the keel will soon be laid for the steam tug for the same company. The contract specifies that the work shall be done by November 10.

Tanker, San Pedro, Cal.—The Southwestern Shipbuilding Company has a contract to build an 8,500-ton tanker for the Traders Oil Company, to be completed by September 30. The Traders, which is affiliated with the American Fuel Oil Company, 70 Broadway, New York, has seven other tankers running between the Pacific Coast and Europe, has placed orders for twenty additional tankers, and is reported to be in the market for forty others. M. B. McQuigg, is president of the Traders.

Passenger Liners, New York.—The American Line, 9 Broadway, is preparing plans and specifications for the construction of several new passenger liners of intermediate sizes in American shipyards. It is probable that at elast three or four of them will be started before many months have elapsed, and upon completion will ply between New York and Southampton. New vessels will also be constructed and purchased for developing the company's New York and Hamburg service.

Tankers, England.—Contracts have been closed for the construction of eleven large steel tankers to be built by Vickers, Ltd., London, and W. G. Armstrong, Whitworth & Company, Ltd., Newcastle-on-Tyne, for Tankers, Ltd., one of the associated firms of Guret, Jacks & Partners, Inc. The contracts call for the construction of six tankers in one lot and five in another. They will be used for transporting oil from California and other oil centers to Vancouver, B. C. and other Pacific Coast ports, Mexico, South America, Europe and the Orient.

Drydock and Shipbuilding Plant, Philadelphia, Pa.—The Dry Dock & Ship Repairs Corporation of Philadelphia will construct a $5,000,000 drydocking and ship repairing plant at Camden, covering 35 acres of ground having a frontage of 1,020 feet on the Delaware River. Plans call for two drydocks with a lifting capacity of 10,000 and 6,000 tons respectively, a marine railway 3,500 to 4,000 tons capacity, machine shops, derricks for handling hea y metals, floating barges, and all welding shops, plate and angle shops, essentials for a first-class ship repairing plant. Operation will start with a working force of from 1,500 to 2,000 men.

PORT IMPROVEMENTS

Channel, Biloxi, Miss.—The City of Biloxi plans to dredge a 26-foot channel to accommodate dredgewater vessels.

Pile, Breakwater, Ocean City, N. J.—E. A. Corson has contract for a pile breakwater and bulkheads at Fiftieth to Sixtieth Street, Ocean City.

Pier, Philadelphia, Pa.—Department of Wharves, Docks and Ferries, Bourse Building, plans to raze and replace the present pier at Chestnut Street, involving $500,000.

Pier and Shed, Bayonne, N. J.—The Gulf Refining Company, 1 Ingraham Avenue, plans to build a pier and steel shed at East Fifth Street, also stock house. About $73,000 and $28,000, respectively.

Dock, Milwaukee, Wis.—Rockwell Manufacturing Company, 572 Park Street, is receiving bids for 230 foot pile and concrete dock, 3 feet capped piles. F. E. Gray, 86 Michigan Street, architect.

Pier, New York.—The Board of Estimate and Apportionment has adopted a resolution providing for a $1,000,000 pier to replace piers 2 and 3, North River. Murray Hulbert, dock commissioner.

Pier, New York.—Murray Hulbert, commissioner of docks, Pier A, North River, let contract for reconstructing pier and new freight pier at Stanton Street to Lustig & Weil, 103 Park Avenue; $117,074.

Breakwater, Corpus Christi, Tex.—The City of Corpus Christi will have a 5,000-foot breakwater constructed along the waterfront by D. M. Piet & Company, contractors, involving an expenditure of $570,000. John T. Bartlett, secretary.

Terminal Company, Fernandina, Fla.—The Fernandina Wharf & Terminal Company was incorporated with a capital of $60,000. Charles J. Davis is president, Jackson Mizell, vice-president, and Louis S. Chadwick, secretary and treasurer.

Port Improvement, Tokio, Japan.—Viscount Tajiri, Mayor of Tokio, who is now in America, says that Tokio is about to expend $175,000,000 on its port for the accommodation of deep-sea ships. At present no vessel exceeding 200 tons can enter.

Dredger, Mukden.—The American Consul at Mukden reports that tenders are desired for a dredger of the trailing suction type, to cost about £130,000, according to engineer's specifications, for use in connection with the Laio River Conservancy.

Drydock, Cavite, P. I.—The Phillippine Government plans to build a drydock on the Cavite side of Manila Harbor, large enough to accommodate the largest merchant vessels. It is estimated to cost 5,000,000 pesos, of which 1,000.000 pesos are immediately available.

Channels, Memphis, Tenn.—Plans are being prepared by the Morgan Engineering Company, Goodwyn Institute, for thirty-mile cut-off channels, from 10 to 100 feet base, in the Grand River, Mo.; 4,000,000 cubic yards drag-line excavation. J. T. Millbanks, chairman.

Municipal Piers, Philadelphia, Pa.—Construction of three municipal piers on the Delaware River between Market and Appletree Streets has been approved. Carroll R. Thompson, assistant director of Wharves, Docks, and Ferries, estimates cost of property and construction at about $4,000,000.

River Improvement.—Navigation of the Connecticut River from Holyoke, Mass. to Long Island Sound, practically is assured by the signing of the water-power bill by President Wilson, according to Charles H. Tenny, president of the Connecticut River Company, which will build a large dam at Windsor Locks, Conn.

Piers, Portland, Me.—Permission to extend the harbor lines 500 feet at the site of the proposed State pier and the Grand Trunk piers was granted by the War Department to the City of Portland, Maine. The extension will permit the construction of the State pier, 1,000 feet long, also widening of the Grand Trunk piers.

Terminal, Camden, N. J.—The Harbor Commission will call for bids at once for the construction of the proposed marine terminal at Spruce Street. Considerable mechanical equipment will be installed, including loading and unloading machinery, conveying apparatus, etc. The pier will be 102 x 485 feet and the terminal proper 86 x 485 feet. Estimated cost about $400,000.

Steamship Terminal Weehawken, N. J.—The Cunard Terminal Company will shortly erect for the Cunard Line, what is expected to be the largest steamship terminal in the world, along the Hudson River near the West Shore Railroad ferry at Weehawken, following the approval a few days ago by the New Jersey Board of Commerce and Navigation of a grant of 1,100 feet of riparian land, at $50 per foot.

Harbor Dredging, Honolulu, T. H.—The entrance to Honolulu harbor will be deepened to insure the safe entrance of large ships. It will be necessary to dredge the docks between piers 6 and 7 to a depth of thirty-two feet, and the slip between piers 16 and 17 to a depth of thirty-three feet. Plans for the construction of sheds of piers 8, 9, and 10 will have to be hastened to handle the volume of freight and passenger travel. Pier 2 is being rushed to completion.

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Coast Harbor Improvement.—A plan to rebuild every harbor and port along the Atlantic coast from Maine to Galveston, and to install new freight-handling machinery to do much of the work now done by men, is suggested in a resolution adopted by the Southwestern Industrial Traffic League, at its meeting in Galveston. This will involve an expenditure of several millions, and introduce machinery and labor-saving devices not now in use, relieving the port congestion caused by strikes.

Graving Dock, Durban.—The site for the new Durban graving dock has been placed at Congella, where a hard bottom was found about 48 feet below the level of low water. The drydock will have the following dimensions: total length from outer caisson, 1,100 feet (divided into two compartments, the outer 660 feet long and inner 440 feet long); width at entrance 110 feet; width at coping, 138 feet 6 inches, width at floor, 110 feet; depth at sill at l.w.s.t., 35 feet; spring tide rise, 6 feet; coping above l.w.s.t., 12 feet; floor of outer end, 40 feet below l.w.s.t.; rise of floor, 1 in 660. Pumping plant is to be provided which will empty the dock in four hours, and the time for filling is 59 minutes. The approach basin is 2,800 feet long, and the proposed width at entrance from the main channel is 1,400 feet long. The construction of the dock was commenced last December and has progressed fairly. The cost of the dock is estimated at £1,300,000.

Drydock, Skinner's Cove, Esquimalt, B. C.—An order in Council was passed by the Dominion Government approving the construction of a drydock estimated to cost about $6,000,000. The proposed dock will have the following dimensions: Length from caisson top to head wall, 1,150 feet; width at entrance, 120 feet; depth on sill at ordinary high water (spring tides), 40 feet; width at coping of dock walls, 144 feet. The structure will be divided into two parts, 650 feet and 500 feet respectively, each part being closed by a steel ship caisson. The dock will be emptied by three centrifugal pumps, each having a capacity of 70,000 gallons per minute. The pumps and other machinery will be operated by a power plant installed on the deck. The walls will be of concrete with granite copings. All keel and bilge blocks will rest on granite strips extending the full length of the dock, and granite will be used for the caisson stops. On the south side of the dock a basin will be formed to allow of repairs, while vessels are afloat and to unload cargoes from vessels before entering the dock. The structure around the basin will be built of reinforced concrete piles.

Harbor Development, Portsmouth, Eng.—The Portsmouth Town Council have decided to purchase a sea frontage at Langston Harbor costing £51,000 for the purpose of establishing a commercial port on that site. Proposed dimensions for the entrance channel are a length of four miles, a bottom width ranging from 600 feet to 700 feet, and a depth of 24 feet at low water springs, which would give a maximum depth at high water springs of 37 feet, 6 inches. Plans for internal work call for a wet dock of 103 acres, the southern portion forming the main basin, and the northern divided into two bays by a central jetty 2,000 feet long. Effective length of wharfage inside the dock would be 13,900 feet, and there would be an additional 7,250 feet at the outside walls. The entrance lock would be 1,000 feet in length, divided into two compartments of 600 feet, and 400 feet respectively. The two tidal quays forming the outside wall would have a depth alongside of 33 feet at low water springs. Under an alternative scheme, three tidal jetties each 3,000 feet in length and 500 feet in width, would be constructed giving a total length of wharfage of 21,400 feet with a depth alongside of 33-feet low water. The cost of the two schemes at prices prevalent immediately before the war is estimated as follows: Entrance channel and training bank £704,000; dock scheme £4,304,000; jetty scheme £4,064,000. This venture is backed by the Portsmouth Corporation.

Government Work

Submarine Base, New London, Conn.—Bureau of Yards and Docks, Navy Department, Washington, D. C., has appropriated $50,000 for the completion of the submarine base at New London.

Power Plant Equipment, Lakehurst, N. J.—The Lord Electric Company, 105 West 40th Street, New York, has contract for furnishing and installing equipment at the naval air station here.

Dredging, Providence, R. I.—United States Engineer let contract for dredging in Housatonic River, Conn., to T. A. Scott Company, Inc., 2929 Pequot Avenue, New London, Conn., $9,600.

Repairing Breakwater, Cleveland, Ohio.—United States Engineer Office, Federal Building, has rejected bids received May 20, for repairing breakwater and placing riprap at Cleveland harbor.

Jetty and Pier Head, Sandusky, O.—United States Engineer Office, Federal Building, Cleveland, let contract for building jetty and pierhead at Sandusky harbor to the Central Dredging Company, Bangor Building, $169,711.

Dredging, Port Gamble, Wash.—U. S. Engineer Office, Burke Building, Seattle, Wash., received only bid for dredging harbor, involving 100,000 cubic yards earth fill, from Puget Sound Bridge & Dredging Co., Central Building, $32,500.

Repairing Piers and Building Superstructure.—United States Engineer Office, 540 Federal Building, Buffalo, N. Y. let contract for repairing and building at Dunkirk harbor to the Empire Engineering Company, North Tonawanda, N. Y.

Marine Railway. Specification 4184.—Bureau of Yards and Docks, Navy Department, Washington, D. C., let contract for elevating and extending marine railway at Naval Air Station to A. M. Hazel, 26 Cortlandt Street, New York, $11,873 (90 days.)

Electric Traveling Cranes.—Specification 4239 Bureau of Yards and Docks, Navy Department, Washington, D. C., plans to build five 40-ton electric traveling cranes for shipbuilding slips at the navy yards at New York, Philadelphia and Norfolk, Va. About $225,000.

Wharf, Boat Basin, Etc., San Diego, Cal—Naval officers have announced that $8,000,000 will be expended at the Naval Air station, North Island, during the next two years. Among the improvements planned are a 100-foot dirigible hangar, concrete wharf and boat basin, concrete launching platforms for seaplanes and a group of barracks and industrial structures.

Harbor Development.—Sealed Proposals, indorsed "Proposals for Harbor Development, Great Lakes, Ill., Specification 4136" will be received at the Bureau of Yards and Docks, Navy Department, Washington, D. C., until 11 o'clock, August 11, 1920, for the construction of breakwaters of three types, rubble mound, rock-filled pile cribs with concrete capping, and sand-filled concrete caisson; the construction of timber pier over existing stone-filled pile and crib breakwater; the construction of timber quay walls; the dredging within the new harbor and the necessary filling with the dredging material behind the quay walls; all at the Naval Training Station, Great Lakes, Ill. Alternative bids will be received for construction of stone-filled timber cribs and sand-filled concrete caissons for certain sections of the breakwater. Drawings and specifications on application to Bureau of Yards and Docks, or to Commandant Naval Training Station, Great Lakes, Ill., $10 deposit, payable to chief of the Bureau of Yards and Docks, required as security for safe return of drawings and specification. C. W. Parks, chief of Bureau.

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